NASA CR-
ERIM 193400-13-P

NASA

Annual Report

REMOTE SENSING IN MICHIGAN FOR LAND RESOURCE MANAGEMENT

1 June 1975 Through 31 May 1976

D.S. LOWE, et al.
Infrared and Optics Division

SEPTEMBER 1976

Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Office of University Affairs, Washington, D.C.
Grant NGR 23-005-552
Mr. Joseph A. Vitale, Technical Monitor

ENVIRONMENTAL
RESEARCH INSTITUTE OF MICHIGAN
FORMERLY WILLOW RUN LABORATORIES THE UNIVERSITY OF MICHIGAN
BOX 618 • ANN ARBOR • MICHIGAN 48107

NOTICES

Sponsorship. The work reported herein was conducted by the Environmental Research Institute of Michigan for the National Aeronautics and Space Administration, Office of University Affairs, Washington, D.C., under Grant NGR 23-005-552. Mr. Joseph A. Vitale is Technical Monitor. Contracts and grants to the Institute for the support of sponsored research are administered through the Office of Contracts Administration.

Availability Notice. Requests for copies of this report should be referred to:

National Aeronautics and Space Administration
Scientific and Technical Information Facility
P. O. Box 33
College Park, Maryland 20740

Final Disposition. After this document has served its purpose, it may be destroyed. Please do not return it to the Environmental Research Institute of Michigan.

TECHNICAL REPORT STANDARD TITLE PAGE

1 Report No	2 Government Accession No	3 Recipient's Catalog No
NASA CR-ERIM-193400-13-P		

4 Title and Subtitle	5 Report Date
REMOTE SENSING IN MICHIGAN FOR LAND RESOURCE MANAGEMENT	September 1976
	6 Performing Organization Code

7 Author(s)	8 Performing Organization Report No
D.S. Lowe, L.B. Istvan, N.E.G. Roller, and V.L. Prentice	193400-13-P

9 Performing Organization Name and Address	10 Work Unit No
Environmental Research Institute of Michigan Infrared and Optics Division P. O. Box 618 Ann Arbor, Michigan 48107 (313) 994-1200	11 Contract or Grant No Grant NGR 23-005-552
	13 Type of Report and Period Covered Annual Report 1 June 1975 through 31 May 1976
12 Sponsoring Agency Name and Address National Aeronautics and Space Administration Office of University Affairs Washington, D.C. 20546	14 Sponsoring Agency Code

15 Supplementary Notes

Mr. Joseph A. Vitale is Technical Monitor for NASA.

16 Abstract

The Environmental Research Institute of Michigan is conducting a program whose goal is the large-scale adoption, by both public agencies and private interests in Michigan, of NASA earth-resource survey technology as an important aid in the solution of current problems in resource management and environmental protection. During the period from June 1975 to June 1976, remote sensing techniques to aid Michigan government agencies were used to achieve the following major results:

1. Supply justification for public acquisition of land to establish the St. John's Marshland Recreation Area;
2. Recommend economical and effective methods for performing a statewide wetlands survey;
3. Assist in the enforcement of state laws relating to sand and gravel mining, soil erosion and sedimentation, and shorelands protection;
4. Accomplish a variety of regional resource management actions in the East Central Michigan Planning and Development Region.

Other tasks on which remote sensing technology was used include industrial and school site selection, ice detachment in the Soo Harbor, grave detection, and data presentation for wastewater management programs.

17 Key Words	18 Distribution Statement
Remote sensing Michigan Land resource management	Initial distribution is listed at the end of this document.

19. Security Classif (of this report)	20 Security Classif (of this page)	21 No of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	79	

PREFACE

This project was performed for the Office of University Affairs, National Aeronautics and Space Administration, by the Environmental Research Institute of Michigan (ERIM) in cooperation with Michigan State University (MSU). The Environmental Research Institute of Michigan, a non-profit corporation, was established on 1 January 1973 as successor to the Willow Run Laboratories of The University of Michigan. This report covers work performed from 1 June 1975 through 1 June 1976; it is one of a series presenting the results of the program.

The goal of this project is to demonstrate the successful use of earth resource survey technology in the solution of problems in land and water resource management of current concern to public agencies.

The investigations described herein were carried out under NASA Grant NGR 23-005-552. Joseph A. Vitale, Chief, Engineering Design Branch, Office of University Affairs, acted as Technical Monitor. The work was performed under the direction of Donald S. Lowe, Deputy Director of the Infrared and Optics Division at ERIM. The program was coordinated with a similar one conducted by Michigan State University under a separate grant.

Project staff members at the Environmental Research Institute of Michigan who participated in this program are listed below. Spheres of responsibility are as indicated; specific task assignments are given in parentheses.

Richard R. Legault, Director, Infrared and Optics Division

Donald S. Lowe, Deputy Director, Infrared and Optics Division

Norman E.G. Roller, Research Associate (wetlands)

Laurence B. Istvan, Research Associate (regional resource management)

Virginia L. Prentice, Associate Research Geographer (sand and gravel mining)

Robert E. Sampson, Research Engineer (fresh grave detection)

Thomas W. Wagner, Associate Research Geomorphologist (Soo Harbor thermal mapping)

CONTENTS

LIST OF FIGURES

LIST OF TABLES

Page
Intentionally
Left Blank

1

INTRODUCTION AND SUMMARY

The Environmental Research Institute of Michigan has continued to obtain results from a wide variety of uses of remote sensing data in connection with problems of interest to state and local agencies, private companies, and citizen groups in Michigan. Many of the accomplishments achieved during the current year were based on continuations of efforts initiated in previous years. It is encouraging to note that a substantial amount of the Grant activity was initiated by groups or agencies that had previously been introduced by ERIM to the potential of remote sensing technology. In responding to requests for assistance, ERIM was able to rely on the previous experience of these groups to carry on the use of remote sensing data without additional major technical support.

Our efforts under the NASA Grant continue to be focused on those applications which show a high probability that remote sensing data will lead to specific useful accomplishments. In the following summary, the specific results of our effort under each task are underlined. Following sections of the report expand on many of the applications. Figure 1 shows the location of these activities.

1.1 WETLANDS PROTECTION AND MANAGEMENT

During the past several years, under the auspices of the NASA Grant, ERIM has conducted a broad program aimed at increasing the use of remote sensing in decision-making by state and local governments in Michigan for wetlands preservation and management. Wetlands are an important resource in Michigan, occupying over 6 percent of the state's total land area and supporting a diverse variety of ecologically important plant and animal communities. In addition, wetlands furnish products of significant economic value. However, undesirable changes in wetlands

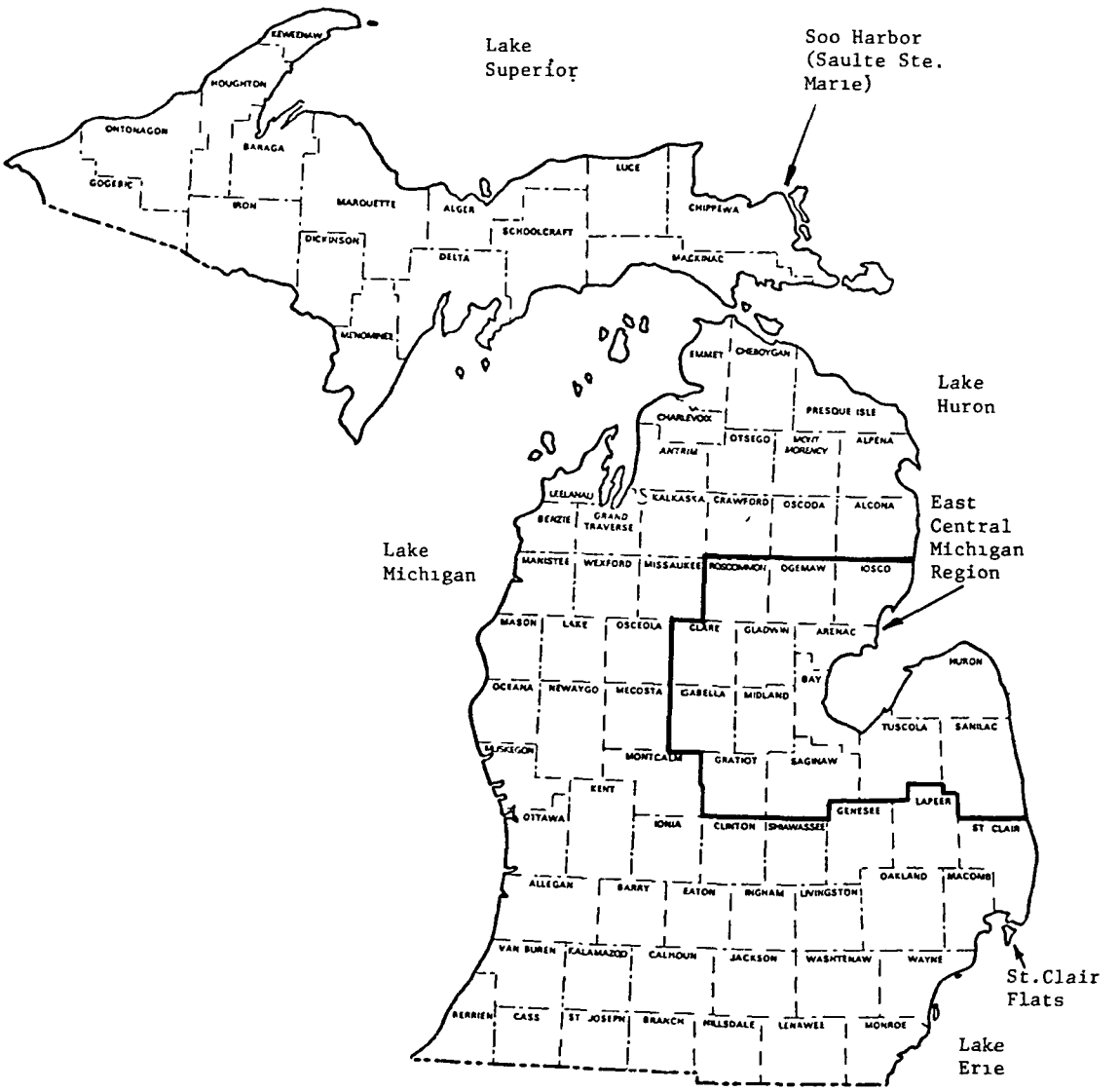


FIGURE 1. LOCATION OF PROJECT ACTIVITIES

result from both human activities and the impacts of natural processes associated with succession. These activities and processes are leading to the rapid destruction of Michigan's wetlands.

Early work by ERIM in wetlands preservation and management has been reported in the previous annual report [1]. The present report updates the activity undertaken by ERIM and describes substantial additional results obtained during the past year.

ERIM's efforts have been directed toward both short-range and long-range goals. Short-range goals center around the preservation and management of wetlands on the St. Clair Flats, including St. John's Marsh, on Lake St. Clair. Long-range goals have been pursued to assist state agency personnel in learning to use remote sensing data and in developing a data base needed to accomplish wetland preservation and management objectives mandated in HB 4618, whose passage by the Michigan Legislature in 1976 is expected. The proposed legislation provides for a state wetlands inventory to be followed by development of a statewide plan for wetlands protection and management.

1.1.1 WETLANDS PROTECTION AT ST. CLAIR FLATS

Remote sensing was used to obtain quantitative data describing wetland condition as a function of changing land use and environmental conditions on the St. Clair Flats, one of the most environmentally sensitive areas in the state. The data generated are being used to support the following management applications: (1) wetlands acquisition, (2) contested wetlands development; (3) decision on extension of leasing rights; and (4) fisheries biology research.

The St. Clair Flats are among the best known of Michigan's wetlands. The area is composed of two large islands (Harsens and Dickinson Islands) and many smaller ones forming the delta of the St. Clair River. This wetland area has been subject to flooding and wave action damage from high water levels in Lake St. Clair in recent years. There has also been a

pattern of dredge, fill, and construction activity which has led to the rapid development of valuable areas.

The State of Michigan is proposing a new and unique environmental recreation area that will involve the purchase of 1260 hectares of St. John's Marsh along the northeast shore of Anchor Bay in Lake St. Clair. The project will not only save a valuable wetland from destruction, but will provide a place where the public can gain a better understanding and appreciation of wetland ecosystems. For this purpose, the State of Michigan is requesting a special appropriation from the Bureau of Outdoor Recreation (BOR) to provide a part of the purchase cost of St. John's Marsh.

An essential part of the program is the preparation of an environmental impact assessment (EIA) to comply with the NEPA requirements for obtaining the necessary federal funds. This assessment is intended to show that without the protection afforded through acquisition and management, the last great block of remaining wetlands under single ownership along Michigan's shoreline will be lost through development and pollution.

For use in the EIA, ERIM furnished the Wildlife and Parks Division of the Michigan Department of Natural Resources (DNR) with remote sensing data and maps demonstrating the ongoing degradation of the area. Space and high-altitude photographs were used to show the area in its regional context. In addition, ERIM prepared a set of 3 maps to show land use and vegetation cover in 1938 and 1974 and the zone of transient wetlands that occurs along the Great Lakes shoreline due to cyclical changes in water level. From these maps, ERIM prepared statistics summarizing changes in land cover and use between 1938 and 1974. Losses and gains in wetlands were evaluated and the forces most responsible for wetlands destruction identified.

Internal DNR review of the entire proposal of which the EIA is a part is set for the fall of 1976. This review will be followed by

hearings before the Michigan Environmental Review Board and public hearings, and any necessary revisions will be made. Assuming that all these steps can be accomplished before March 1977 and project approval obtained from BOR, FY 78 funds will be allocated to go ahead with the project.

We expect that the remote sensing data and imagery used in the St. John's Marsh EIA will also be used by the Lake St. Clair Advisory Committee and other citizen conservation groups promoting the preservation of the marsh.

In addition to its use in the public acquisition process, remote sensing has been applied for other purposes. Part of the St. John's Marsh is the site for a proposed luxury condominium with more than 400 boatwells. The Blue Water Isles Realty Co. wants to put in multi-unit structures complete with boatwells, canals, and parking for 1000 cars on 60 acres just north of Old Colony Suddivision. Although the Clay Township Planning Board has given preliminary approval, area residents have strongly opposed the development at public hearings. Before the project could proceed, DNR permits were needed to dredge, fill, and install sewers. Based on the analysis of the EIA prepared for the area, DNR has denied the permits. This judgment will be appealed in the courts. DNR intends to use the evidence generated by ERIM's analysis of NASA-furnished remote sensing data to justify its action on the permit request.

The St. Clair Flats Land-Use Policy Committee is made up of members of many agencies within the DNR. The Committee is presently concerned with decisions on the continuation of leasing rights to cottage owners. Using Michigan shoreline photography for 1938 and 1974 and recent U-2 photography collected under the NASA program, ERIM prepared an inventory for 93 sq. km of the Lake St. Clair shoreline and delta islands. The cover type mapping system used was the Michigan Land Cover/Use Classification System developed by the Land Use Programs

Division. Based on the inventory data, change detection statistics were derived by ERIM. Each committee member is reviewing the material supplied by ERIM to help formulate his personal recommendation on the issue of continued leasing rights.

Lake St. Clair is currently the site of an ongoing Fish and Wildlife Service (FWS) study being conducted by the Great Lakes Fish Laboratory to determine the role of fresh water marshes as spawning grounds and nurseries for larval fish. FWS is conducting a two year study in certain locations in Lake St. Clair to study the relationships between different types of shallow water shoreline habitat and larval fish survival. To select sampling stations, FWS has studied NASA photography of St. John's Marsh. In the process, the ability to identify several other factors possibly related to fish survival was discovered, such as the spatial relationships among various types of vegetation, and the effects of varying water levels on vegetation. If the preliminary field work being conducted by FWS indicates that vegetation mapping can be used to identify areas critical to fish survival, a larger area inventory using remote sensing will be carried out by FWS in late 1976 or in 1977. The resulting survey could lead to a more intelligent setting of catch limits and an improved program of habitat and commercial fishing management.

1.1.2 STATEWIDE INVENTORY AND MANAGEMENT

Legislation has been introduced aimed at preserving up to one million acres of Michigan's wetlands. The proposed legislation (HB 4618) provides for a state wetlands inventory to be followed by development of a statewide plan for wetlands protection and management, which may be administered by local governments, if they qualify. It is currently expected that the bill will be passed in 1976.

Thus it is very likely that within two years both state and federal wetlands inventories will be carried out for the State of Michigan. Michigan will get the mandate to do its own wetlands inventory from

the passage of the pending wetlands bill. At the federal level Michigan is currently scheduled to be one of the first states completed as part of the National Wetlands Inventory sponsored by the Fish and Wildlife Service. In support of both these efforts a central objective of ERIM's effort has been to aid various groups in the Michigan Department of Natural Resources in selecting the most effective remote sensing techniques for use in a statewide wetlands inventory and providing guidelines for the use of remote sensing in the everyday management of wetlands. These types of information have been made available to potential users through participation in workshops and presentations at user conferences. At the present time, a technical report "Remote Sensing of Wetlands" is being prepared to explain how to apply remote sensing techniques to wetlands inventory and analysis both effectively and economically.

Once the state wetlands bill (HB 4618) is passed, DNR will be requested to conduct a statewide survey of Michigan's wetland resources within 18 months. ERIM is working closely with DNR to evaluate a strategy based on remote sensing for producing a useful inventory at reasonable cost and within the required time. A major aspect of this task has been to help plan the collection of 1:24,000 color infrared photography of the entire State. This coverage would be useful to a variety of state and federal agencies. ERIM is currently involved in helping to develop an inventory plan for which financial support can be provided jointly by these agencies and which would benefit all of the groups. ERIM is providing technical advice on such considerations as film scale and film type, and data acquisition and interpretation costs.

Further information on wetland protection and management is given in Section 2.

1.2 ENVIRONMENTAL PROTECTION

During the current year, ERIM laid the groundwork for using remote sensing to promote and envorce environmental legislation. This effort centered on the Sand Dune Mining Act, which was enacted into law in

mid-1976, and the Soil Erosion and Sedimentation Act of 1972, for which enforcement agencies and procedures are in existence. ERIM's activities have resulting in making public interest groups and state and local agencies aware of the potential of remote sensing for these purposes. Assistance has been given in specific cases, and ERIM is continuing to work toward extending the application of remote sensing to additional cases as they arise.

ERIM has cooperated with the West Michigan Shoreline Regional Development Commission (WMSRDC) and the West Michigan Environmental Action Council (WMEAC) in attempting to induce local zoning actions and state legislation to protect recreational and environmental areas against damage from sand and gravel mining operations (Section 3). High altitude color IR aerial photos supplied by ERIM were used as part of a public information program undertaken by WMEAC. The Sand Dune Mining Act, which WMSRDC and WMEAC have been active in promoting, has now become law.

ERIM is also cooperating with citizen groups and public agencies in encouraging the use of remote sensing to monitor earth change activities which may violate the Soil Erosion and Sedimentation Act of 1972, and to document such violations for enforcement action (Section 4).

1.3 GREAT LAKES SHORELANDS ZONING

Nearly two years ago, ERIM developed a photogrammetric technique using historical and current aerial photography for estimating the erosion rate of Michigan's Great Lakes Shoreline [1]. The technique was subsequently used by DNR to calculate the erosion rate for the entire Michigan shoreline. Such information was used to establish zoning restrictions in the coastal area, either by zoning ordinances formulated by township or county planning officials, or by DNR if these officials did not act.

To date, zoning restrictions are in force for the entire shoreline, built around the erosion rate guidelines developed by the ERIM technique. For about 30 percent of the shoreline, zoning restrictions were formulated by local officials. Of the 30 percent, one-third were plans submitted by local officials and approved by DNR. The remaining two-thirds are plans submitted by local officials and currently undergoing DNR approval. For the remaining 70 percent of the shoreline, the DNR is controlling development in high erosion rate areas through a construction permit system.

The effectiveness of the technique is apparent from the fact that (1) the erosion rate results have been accepted, either directly or de facto, by all coastal townships; (2) to date there has been only one challenge to the regulations arising from the erosion rate data. In that case, settled by the DNR Environmental Review Board rather than in court, the developer was able to present enough additional information to convince the Board that he should be allowed to develop his site. The erosion rate data, however, was not questioned.

While it is too early to say that the project is an unqualified success, evidence to date indicates that the NASA Grant program was instrumental in developing an erosion rate measurement technique which gave state and local officials the information to formulate realistic planning restrictions in high erosion rate areas of Michigan's coastal zone.

1.4 REGIONAL RESOURCE MANAGEMENT

A program for developing applications of remote sensing in regional resource management was carried out in cooperation with the East Central Michigan Planning and Development Regional Commission, located in Essexville, Bay County (Section 5). ERIM planned a high-altitude aircraft photographic mission which was flown by NASA on 29 July 1975. A training workshop was then conducted for regional staff

members. Since January 1976, the regional commission staff and representatives of local government agencies have made extensive use of the imagery for many purposes.

Specific results of using the imagery provided by NASA include the following:

- In support of the region's Coastal Zone Management (CZM) Program, wetlands, shore erosion, and land use have been mapped as a prerequisite for implementation of the management plan to be created under the state CZM program. The remote sensing data have also been used in debates over specific rulings on areas to be put under restrictive use and in at least one case provided the evidence needed for reversing a decision on land use.
- High-altitude photography has been used for preliminary identification of potential sites of sewage treatment plants.
- Ground truth information was provided for LANDSAT mapping of the entire 20,000 sq. km region carried out to provide basic data for the region's Section 208 Areawide Wastewater Management Program, aimed at maintaining or improving the surface water quality of the region.

1.5 SITE SELECTION

1.5.1 INDUSTRIAL SITE LOCATION

The Martin-Marietta Corporation is interested in finding sand and gravel deposits in the Southeast Michigan area and contacted the Office of Economic Expansion of the Michigan Department of Commerce to assist them. At the request of OEE, ERIM provided Martin-Marietta with RB-57 photography of the area to assist them in preliminary location of potential sites. Using this remote sensing data in conjunction with ground checks, Martin-Marietta was able to locate a 340 hectare site in the Oakland-Macomb County area, and is now conducting soil tests on this site to determine its suitability for their purposes.

1.5.2 SCHOOL SITE SELECTION

ERIM supplied Dr. Karl S. Peterson, Principal of the Huron Valley Lutheran High School with information that was used in the selection and evaluation of a 10 hectare site for a future school. The aerial photography supplied to Dr. Peterson and other data on soils, vegetation, and topography was obtained from ERIM's 1972 study of the M-14 freeway extension conducted under the NASA Grant [2]. This information was instrumental in the decision to purchase the site for $108,000.

1.6 THERMAL EFFLUENTS IN SOO HARBOR

Thermal imagery collected during the Michigan shoreline flight program of April and May 1974 was used to identify possible point sources of thermal effluents into the Soo Harbor at Sault Ste. Marie, Michigan (Section 6). These point sources are believed to be responsible for melting and detaching ice from the shoreline, thereby causing ice jams in the Little Rapids Cut downstream of the harbor.

1.7 FRESH GRAVE DETECTION

ERIM is cooperating with local law enforcement agencies to provide them with information concerning the operational utility of thermal mapping methods for fresh grave detection. The ability to detect graves no more than a few months old has been demonstrated using a Thermovision system and practical procedures for using airborne sensing systems to search over areas of a few hundred hectares are being outlined (Section 7).

1.8 DATA PRESENTATION FOR WASTEWATER MANAGEMENT STUDIES

ERIM was under contract with the Toledo Metropolitan Area Council of Governments (TMACOG) during 1975-76 to supply land cover/use data for use in EPA PL92-500, section 208 studies. The TMACOG area covers

portions of seven counties in southeastern Michigan and northwestern Ohio. During the course of the work, we found that a quick, inexpensive color map production capability was needed in order to inform local and county planners of the nature of the land resource/use mapping effort and to act as a point of departure for water quality planning discussions.

At about the same time, the color ink jet printer (IJP) of the Multivariate Interactive Data Analysis System (MIDAS), being built for NASA by ERIM, became available. Under grant funding, a preliminary set of color coded maps were prepared for evaluation by TMACOG.

Their response was enthusiastic. Everyone who saw the maps was impressed. To date, TMACOG has invested about $5,000 of its various project monies to obtain color maps of level I and II land use, septic suitability, depth to high water table, and soil permeability. The map data have been derived from land resource/use and soils information digitized under TMACOG-EPA sponsorship.

1.9 USER ASSISTANCE

During the last grant year, ERIM continued to promote the utilization of existing high altitude aerial photography and LANDSAT imagery by many other user groups. Many of these users requested copies of photography or of interpretation products, after having searched the existing photographic coverage in ERIM's imagery vault. We provided technical assistance to those users who were uncertain of their exact imagery requirements. A list of these visitors is presented in Table 1.

TABLE 1

IMAGERY PROVIDED TO LOCAL USERS, 1975-76

USER	REQUIREMENT	PRODUCT USED/SUPPLIED
Mercy College, Detroit	Photo of Detroit for front cover of proposal	SKYLAB-3 red band image of Detroit
Ed Limoges, Washtenaw County Metropolitan Planning Commission	Update land use map for two townships	1974 and 1975 high altitude CIR photography loaned
Southeast Michigan Council of Governments, Detroit	Color photography for seven county area to make land use map for EPA PL92-500, section 208 study	Loaned 1975 high altitude CIR photography for duplication
West Michigan Sand and Gravel Association	Photography showing historical data of sand mining operations in Western Michigan	Prints of 1969 high altitude color and color IR photography
State Senator John Otterbacher, Grand Rapids	Recent state land use information	Copy of State of Michigan Land Use Map compiled from LANDSAT and aircraft imagery

FIGURE 2. BEAVER POND IN NORTHERN MICHIGAN

Michigan's wetlands constitute one of its most valuable resources. A state program to protect wetlands will rely on remote sensing to supply current information needed to plan the preservation and management of these areas.

MICHIGAN'S WETLANDS: SAVED OR PAVED?

During the past several years, under the auspices of the NASA Grant, ERIM has conducted a broad program aimed at increasing the use of remote sensing in decision-making by state and local governments in Michigan with regard to wetlands preservation and management. This section of the report summarizes work on that program reported in the preceding annual report (Ref. 1) and reviews the progress made during the current reporting period.

ERIM's efforts have been directed toward both short-range and long-range goals. Short range goals center around the preservation and management of a critical and threatened wetland on Lake St. Clair, the St. Clair Flats, including St. John's Marsh. ERIM has provided the Michigan Department of Natural Resources with needed information in support of the State's plan for public acquisition of 1260 hectares of the St. John's Marsh to be converted to the St. John's Marshland Recreation Area.

Remote sensing data were used to study past trends in destruction of the marsh through urban development and natural processes and to evaluate the current condition of the marsh. This information has been used by the state in the preparation of the environmental impact statement needed to justify public acquisition and project funding.

Long-range goals have been pursued to assist state agency personnel in learning to use remote sensing data and in developing the data base needed to accomplish wetland preservation and management objectives mandated in HB 4618, whose passage in 1976 by the Michigan Legislature is expected. The proposed legislation provides for a state wetlands inventory to be followed by development of a statewide plan for wetlands protection and management. ERIM is participating in the planning of a comprehensive wetlands inventory to be conducted by the state and is providing needed information on the most effective and economical remote sensing methods of wetland inventory and analysis.

2.1 THE ISSUE

Wetlands are an important resource in Michigan. They occupy over six percent of the state's total land area of 57,890 square miles and constitute the dominant feature of the landscape in many areas. Wetlands have an intrinsic ecological value because they support a diverse variety of important and often unique plants and animals. They also provide tangible economic benefits by furnishing products of commercial value and supporting several types of outdoor recreation.

Although previously considered only wastelands, wetlands are now generally accepted as important and worth protecting. This task is complicated, however, by the fact that very little inventory data on wetlands exists and it is not apparent whether the resource is receiving adequate protection, while at the same time, contributing at maximum potential to individual prosperity and public benefit.

Thus, the true extent of the wetlands problem in Michigan is not accurately known, although it is recognized that wetlands are being lost at an increasing rate and that those which remain are being damaged by pollution and poor land use practices on surrounding land. The factors responsible for causing these undesirable changes are of two basic types: (1) damage caused by the activities of people, and (2) the impacts of natural processes associated with ecological succession.

2.2 PUBLIC ACQUISITION OF ST. JOHN'S MARSH

As discussed in Reference 1, the State of Michigan is proposing a new and unique environmental recreation area in the Detroit Metropolitan area that will involve the public purchase of 1260 hectares of wetlands along the northeast shore of Anchor Bay, Lake St. Clair (see Figure 3). The resulting St. John's Marshland Recreation Area will be a first for Michigan. It will not only save a valuable wetland from destruction, but, at the same time, will provide a place where the public can gain a better understanding and appreciation of wetland ecosystems and their relationships in the "web of life."

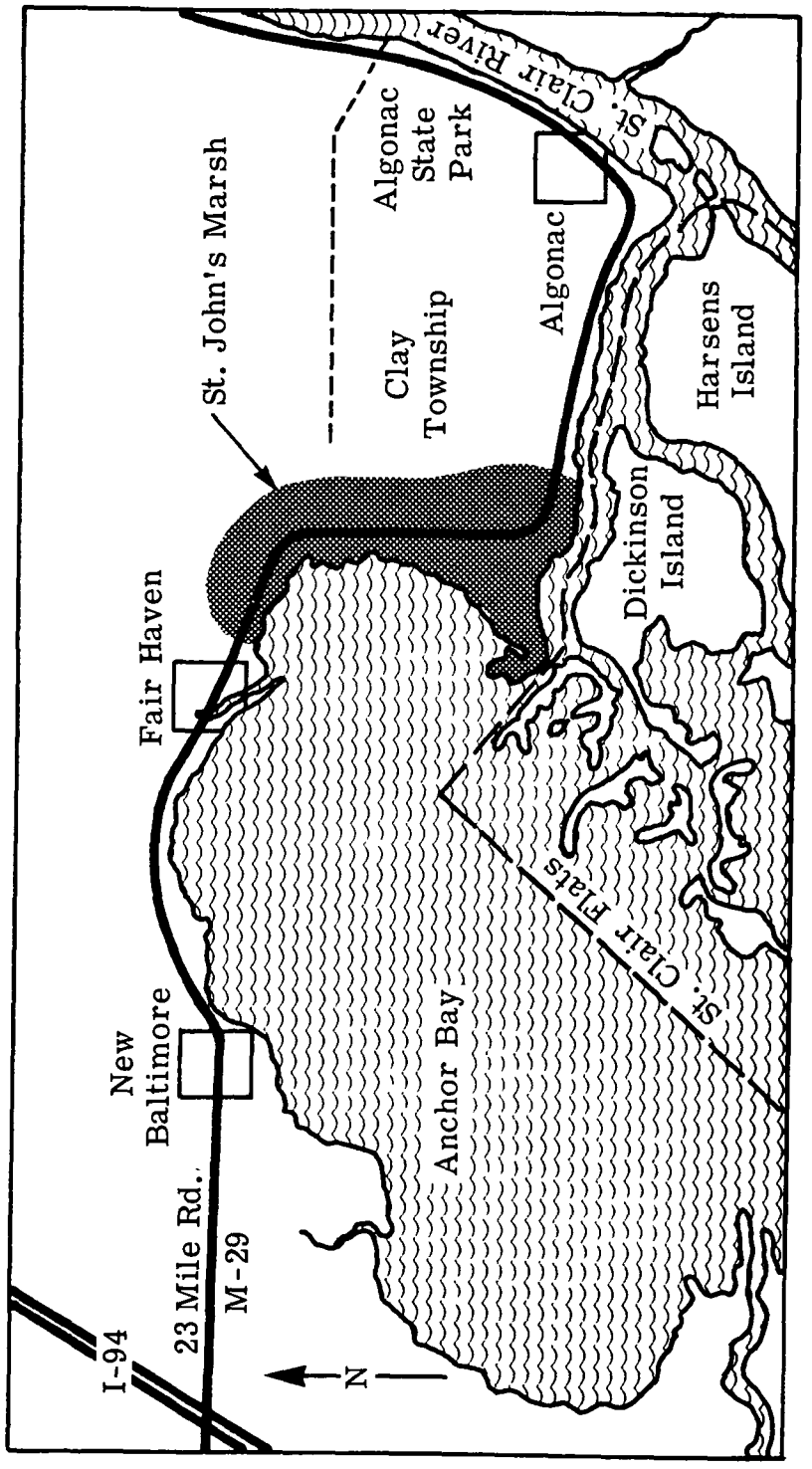


FIGURE 3. WETLAND AREAS ON LAKE ST. CLAIR

2.2.1 LEGISLATIVE ACTION FOR PUBLIC ACQUISITION

Because the projected use of Michigan's regular annual apportionment of federal Land and Water Conservation Funds for Michigan Department of Natural Resources (DNR) projects will exceed monies available in each fiscal year in the foreseeable future, the State of Michigan is seeking a special appropriation from the Bureau of Outdoor Recreation (BOR) to assist in the purchase of St. John's Marsh. This special appropriation will provide 50 percent of the funds to accomplish the first of the project's two acquisition phases. Phase One will concentrate on the immediate purchase of the undeveloped wetlands and related open farmlands along the north and east project boundary lines. Phase Two is a long-range plan to purchase the remaining developed areas as parcels become available.

The cost of the Phase One acquisition, which involves 1,260 hectares of land, is anticipated to be approximately $3 million. Of this total, the State of Michigan will request $750,000 from the Secretary of Interior's Contingency Reserve Fund and $750,000 will come from the State's regular BOR apportionment. The remaining funds will be 50 percent matching money provided by the State. Four prominent state representatives, in a bipartisan effort, are currently involved in developing legislative support for a budget item in the 1977 DNR capital outlay request. As a result of the actions of these individuals, the Legislature has already approved a preliminary appropriation of $250,000 to take up options on the marsh, but no action is expected to be taken until all appraisals and negotiations are complete.

2.2.2 ENVIRONMENTAL IMPACT ASSESSMENT

An essential part of DNR's Phase One program is the preparation of an environmental impact assessment (EIA) to comply with the NEPA requirements for obtaining federal funds. The posture take by the Michigan Department of Natural Resources in preparing this assessment

is that without the protection through acquisition and management, St. John's Marsh will be lost through development and pollution. This would be a major public and ecological loss.

To support its viewpoint, DNR needed information that (1) illustrated the unique ecological nature of the marsh, and (2) quantitatively identified the pressures which are slowly degrading its quality. To assist the DNR, ERIM furnished the Wildlife and Parks Division of DNR with a number of remote sensing products which they have used in the analysis of the problem and preparation of the EIA.

A SKYLAB S190A photo was used to portray the regional and cultural setting of the project, and NASA high-altitude aerial photography was used to show the local situation. Low level obliques of the marsh provided by the NASA Grant were useful in illustrating the activities DNR feels are responsible for degrading the quality of the area. A set of 3 maps was prepared by ERIM showing land use and vegetation cover of St. John's Marsh in 1938 and 1974 and the zone of transient wetlands that occurs along the Great Lakes shoreline due to cyclical changes in water level (see Figure 4).

Using a cell-by-cell tabulation method, with a cell size of 1 acre (0.4 hectare), statistics were generated which document the amount of the project area in each land use or cover type category present (Figure 5). Comparison of the category codes of a single cell for the two dates made it possible to identify the causes behind changes in the wetlands over the years.

The analysis of a total area of 2260 hectares showed that the total urban/built up area increased from 127 hectares in 1938 (6 percent of the total area) to 320 hectares in 1974 (14 percent of the total area), an increase of 8 percent (Figure 6). This trend will probably continue unless effective land use regulation is undertaken. The analysis also indicates that during this same period, total wetlands area increased from 388 hectares (17 percent of the total area) to 790 hectares (35 percent), an increase of 18 percent. This gain occurred in spite of

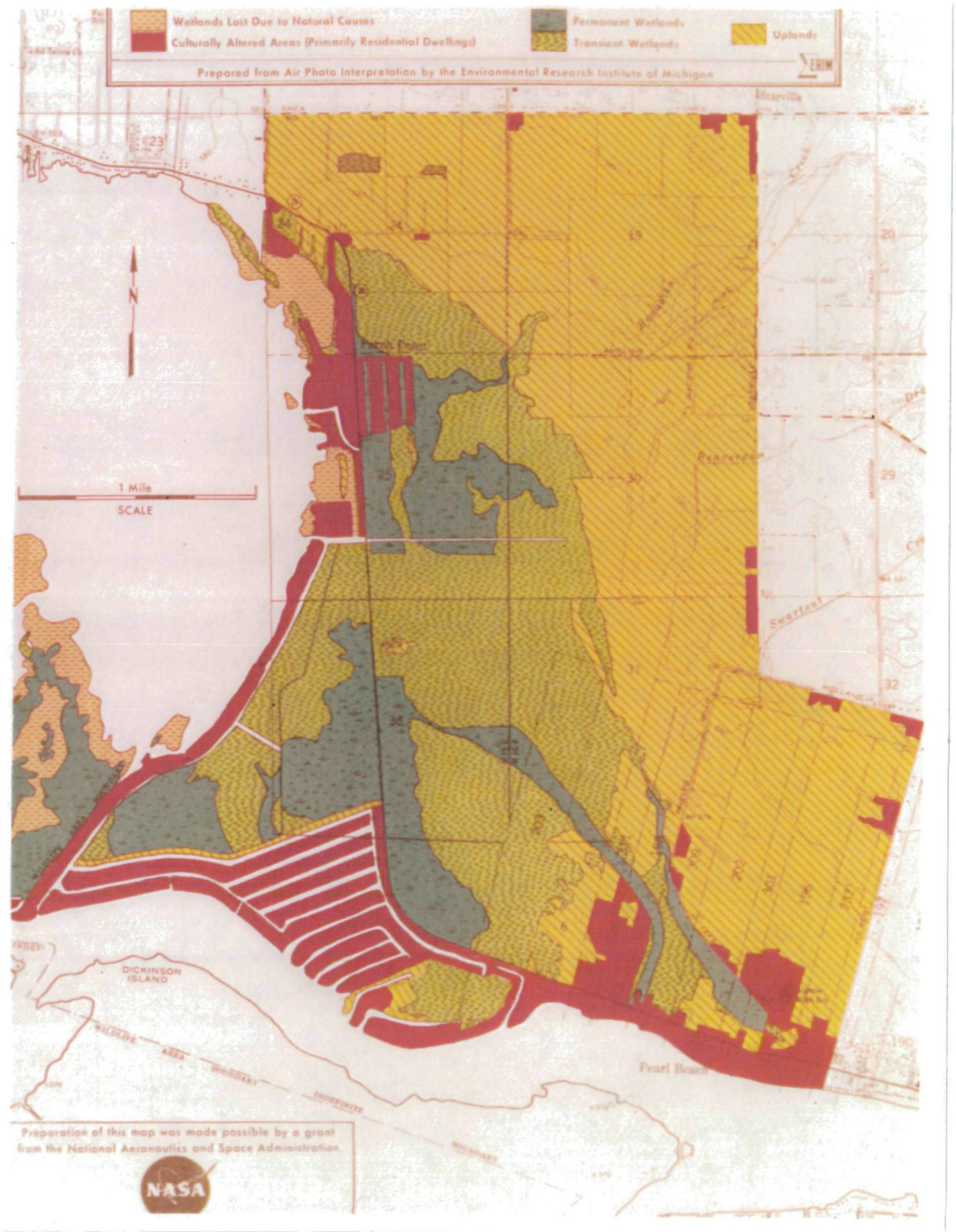
FIGURE 4. TRENDS IN WETLAND CHARACTERISTICS AND RESIDENTIAL DEVELOPMENT IN ST. JOHN'S MARSH.

The State of Michigan is proposing to establish a new and unique environmental recreation area that will require the public purchase of 1260 hectares of wetlands along the northeast shore of Lake St. Clair. The resulting St. John's Marshland Recreation Area will save a valuable wetland from destruction by both natural and cultural pressures and will offer the public an opportunity to observe and appreciate wetland ecosystems.

Remote sensing has been used to develop data needed to justify the appropriation of state and federal funds to purchase and preserve the marsh areas. These data have been used in the preparation of an environmental impact assessment prepared by the Michigan Department of Natural Resources which illustrates the unique ecological nature of the area and quantitatively identifies the pressures now degrading its quality.

The remote sensing used to document the changes in St. John's Marsh consisted of a comparison of 1938 ASCS 1:20,000 panchromatic air photos with 1974 NASA 1:10,000 color photography. This comparison shows both long-term land use trends over a 36-year period and the effect of cyclic variations in the water level of Lake St. Clair. In 1938 a low lake level of 572.68 ft. IGLD (Algonac Station) existed, while in 1974 one of the highest lake levels occurred (576.11 ft. IGLD).

The high lake levels have a major effect on the extent of wetlands. Comparison of photography for the two dates shows where rising water, and wave and wind action have resulted in the destruction of wetlands along the shoreline, while inland transient wetlands have been created due to the landward encroachment of the water table at high lake level. The transient wetlands have high ecological value and are unsatisfactory sites for residential development. Long-term trends in residential development during the interval were also identified. This trend toward measuring residential development of wetlands can be arrested if the proposed plan for public acquisition and preservation of marsh areas is carried out.


Wetlands Lost Due to Natural Causes
Culturally Altered Areas (Primarily Residential Dwellings)
Permanent Wetlands
Transient Wetlands
Uplands
Prepared from Air Photo Interpretation by the Environmental Research Institute of Michigan
ERIM
N
1 Mile
SCALE
Marsh Point
DICKINSON ISLAND
Pearl Beach
Preparation of this map was made possible by a grant from the National Aeronautics and Space Administration.
NASA

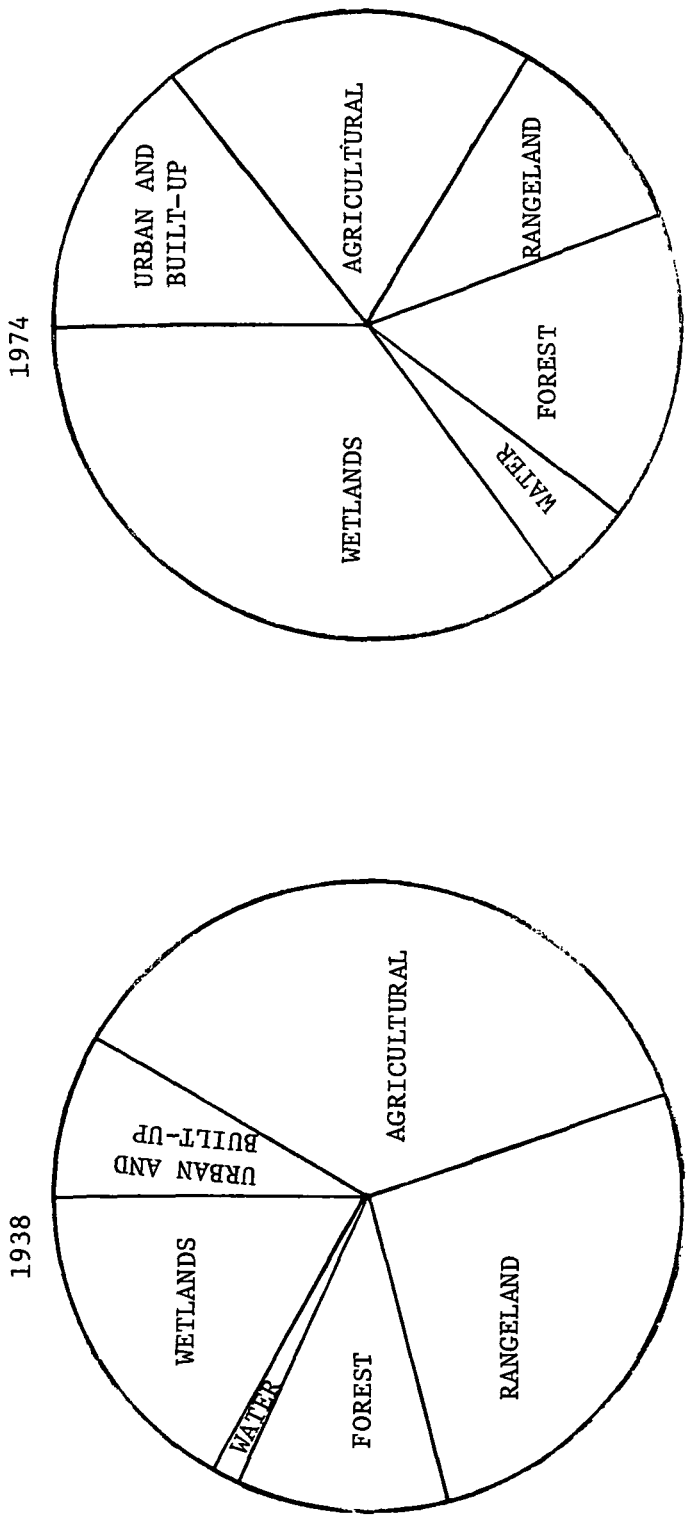


FIGURE 5. CHANGES IN ST. JOHN'S MARSH, 1938 TO 1974

FIGURE 6. MARINA ON LAKE ST. CLAIR

the fact that residential encroachment replaced 67 hectares of permanent wetlands (3 percent of the total area). The net increase in wetlands was primarily transient wetlands, the result of higher lake levels which existed in 1974, and the trend will be reversed as lake levels fall. If lake levels again fall to those existing in 1938, the total wetlands area will show a net decrease over the complete cycle. An important conclusion of this trend analysis is that these transient wetlands have high ecological value as a wetlands area and at the same time are exceedingly unsatisfactory for residential development. The results of this work, which was performed in mid-1975, were presented to the DNR in an informal report [4].

Internal DNR review of the proposal to BOR, of which the EIA is a part, is set for the fall of 1976. This review will be followed by hearings before the Michigan Environmental Review Board and public hearings. When these hearings are completed and any necessary revision made, the proposal will be submitted to BOR for action.

A preliminary proposal was submitted last year by DNR to BOR to get their reaction to the desirability of such a project. This preliminary proposal received a favorable review, and there is every indication that a convincing EIA will result in approval of the project. NASA imagery was also featured in this preliminary proposal.

If all necessary steps can be accomplished before March 1977, it is possible that upon project approval, Fiscal Year 78 funds will be allocated to go ahead with the project.

2.2.3 FUND DRIVE TO ACQUIRE ST. JOHN'S MARSH

The action of the State of Michigan is not the only activity directed toward acquiring St. John's Marsh for public use and preserving it from the pressures of speculative development. The Lake St. Clair Advisory Committee, a local group of citizens, is helping the DNR save the marsh by drawing attention to the project, informing interested persons, and securing adequate in-state funding to qualify for essential

federal matching funds.

The Committee is concerned with the fact that the value of the marsh as a public asset is being overshadowed by the potential value of the land area for development. The greater the increase in surrounding land values from urbanization, the greater the temptation to take advantage of the low market price of wetlands, which is not a true indicator of their value.

Clay Township, St. Clair County, occupies the delta formed at the outlet of the St. Clair River, and surrounds and includes the St. John's Marsh. The population of Clay Township has almost tripled since 1950, and the trend continues, as people continue to move out of the congested Detroit urban area. The average family moving into the area is interested in being on or near the water, a demand which has encouraged developers to concentrate on the shore of Lake St. Clair and the channels of the St. Clair River. As indicated previously, this development pattern has consumed large amounts of natural wetlands already and will continue to do so until the wetlands are destroyed.

The Future Land Use Plan of St. Clair County, recognizing the ecological value of the area, recommends St. John's Marsh be used for recreation and open space uses. The Clay Township Planning Commission, however, plans to zone the area for residences, seven school sites, two shopping centers, and a fire station. Natural areas will be confined to two small parks.

With time running out, the Lake St. Clair Advisory Committee began a "save the marsh" drive in Marsh 1976, donating $5000 of its own funds. Since that time additional contributions have upped the total to nearly $20,000. Another bright spot is the passage of the State Duck Stamp Act. This law requires Michigan waterfowl hunters to buy a $2.10 license in addition to a small game and Federal Duck Stamp. DNR officials estimate this Act alone will bring in $80,000 of revenue annually for the acquisition of wetlands.

The remote sensing data and imagery used in the St. John's Marsh EIA will also be used by the Lake St. Clair Advisory Committee and others promoting the preservation of the marsh.

2.2.4 WETLANDS DEVELOPMENT CONTESTED

Part of the St. John's Marsh is the site for a proposed luxury condominium with more than 400 boatwells. The Blue Water Isles Realty Co., co-owners of the marsh with the St. John family, wants to put in multi-unit structures complete with boatwells, canals, and parking for 1000 cars on 60 acres of marsh just north of Old Colony subdivision. The units would rent for $300 per month (see Appendix A).

Although the Clay Township Planning Board has given preliminary approval, area residents have unanimously opposed the development at public hearings. Township officials support the project on the basis of the tax revenue it will generate. Before the project can proceed, however, DNR permits are needed to dredge, fill and install sewers. Based on the analysis of the EIA prepared for the area, described in Section 2.2.2, DNR has denied the permits. Henry Perkowski of Algonac, the representative of the developer, has indicated that he plans to appeal the judgment and demand that the DNR show cause. In that event, DNR intends to use the evidence generated by ERIM's remote sensing analysis of NASA-furnished data to justify in court its denial of development permits on the grounds of irreversible and extensive ecological damage.

2.3 EXTENSION OF LEASING RIGHTS IN ST. CLAIR FLATS AREA

The St. Clair Flats Land-Use Policy Committee is made up of members of many agencies within DNR. Committee members periodically review the progress made towards achieving the objectives designated as the land-use management policy of DNR for the St. Clair Flats area. This was last done in 1965.

As already noted, the St. Clair Flats is a unique and valuable natural area. A major task of this committee is to evaluate what the

impact of human activity is upon the natural values of this area (see Fig. 7). A major consideration is the perpetuation of leasing rights to cottage owners. Under a 1913 law, in which the state purchased most of this area, 49-year leases plus an option to renew for another 50 years were granted to many previous land owners. The original term ended in 1962 and DNR must decide if it wants to give an additional option to extending their lease beyond 2012. As a basis for making this decision the committee is trying to assemble all available information describing changes in the area and the impact of these changes on the quality of the wetlands.

ERIM has provided the committee with cover type maps of 93 sq. km along the shoreline of Anchor Bay, as it was in 1938 and 1974, along with change detection statistics for St. John's Marsh. The Land Use Programs Committee has made copies of these maps to enter in the state's land use information data base. Each member of the committee will be reviewing the supplied material to help formulate his personal recommendations which will be integrated into a committee report and become the DNR policy for the St. Clair Flats area.

2.4 GREAT LAKES FISHERIES MANAGEMENT

Lake St. Clair is currently the site of an ongoing Fish and Wildlife Service (FWS) study being conducted by the Great Lakes Fish Laboratory to determine the role of fresh water marshes as spawning grounds and nurseries for larval fish. Lake St. Clair is of particular interest to FWS because fish tagging studies have shown that perch and walleye migrate over 160 km from Lake Erie and Saginaw Bay to spawn there. One theory as to why this occurs is that the habitat conditions in the marshy areas favor survival of the fry.

To investigate this hypothesis FWS is conducting a two year study in certain locations in Lake St. Clair to study the relationships between different types of shallow water habitat and larval fish survival. To select sampling stations FWS has studied NASA photography of St. John's

FIGURE 7. BLOCK DEVELOPMENT ALONG MIDDLE CHANNEL OF BRUCKNER ISLAND.

Marsh. In the process several other factors possibly related to fish survival were discovered, such as amount of habitat created by shoreline development practices, the juxtaposition of aquatic floating and emergent vegetation, and the effects of varying water levels in Lake St. Clair on habitat availability. FWS is very much interested in the capability, demonstrated by remote sensing over a small area, to identify and map these types of vegetation. If their preliminary field work shows that these areas are in fact critical to fish survival, a larger area inventory to identify these habitats funded by FWS is a possibility for later in 1976 or in 1977.

The fundings of such a survey are of great importance. For example, one of the most significant outcomes would be the ability to estimate walleye production for all of Lake St. Clair. This in turn could lead to a more intelligent setting of catch limits and an improved program of habitat and commercial fishing management.

2.5 STATEWIDE WETLANDS MANAGEMENT

2.5.1 NEW LEGISLATION

Legislation has been introduced in the state capital aimed at preserving up to one million acres of Michigan's wetlands, including some of its environmentally most valuable and most frail areas. In 1975, a "wetlands" bill was introduced in the House of Representatives, but it did not get out of committee. Opposition by the Michigan Farm Bureau and forest industry to an overly inclusive definition of wetlands is generally considered to have been the major stumbling block.

This problem of defining wetlands in an acceptable manner was solved when the bill (HB 4618) was reintroduced this year by Rep. Warren Goemare. The definition of wetlands was tied to those areas contiguous to lakes, rivers, and streams that have some 40 species of hydrophytic plants growing on them. As currently written, the bill does not cover isolated wetlands, which number in the thousands in Michigan. Although this is regrettable, it is also true that the most productive wetlands are those

adjoining large bodies of open water, such as St. John's Marsh on the eastern shore of Lake St. Clair, or the marshes of Saginaw Bay.

In summary, the proposed legislation provides for a state wetlands inventory, to be followed by regulation of wetlands and development of a statewide plan for wetlands protection and management, which may be administered by local governments if they qualify.

The bill is currently on the calendar for its second reading in the House of Representative. According to Doug Reece, House Conservation Committee aide, the bill is expected to pass the House without difficulty in September 1976. The bill is then expected to pass in the Senate also, because it is a popular issue in an election year in the state. Thus, there is every indication that 1976 is the year Michigan will finally get the mandate it needs to protect its valuable wetland resources effectively.

2.5.2 CURRENT WETLANDS INVENTORY DATA REQUIRED

Although other resources, such as timber and water, have been managed on a statewide basis for years, interest in extending this approach to wetlands is only of recent origin. Previously, management of wetlands was carried out with funding allocated for work in specific localities on a piecemeal project-by-project basis. Comprehensive management of the state's wetland resource is preferable on the grounds that it will provide a better means of seeking funding and decision-making.

HB 4618 requires that an inventory of state wetlands be prepared to determine the location of areas that require protection and the type of protection best suited for each particular area. Within 18 months after the effective date of the act, DNR will prepare a plan for the use, management, and protection of wetland areas. This plan will result in further studies and research, enactment of necessary enforcement powers and legislation, and regulation of residential, industrial and commercial development affecting wetlands. The bill will prohibit persons from depositing or removing material in a wetland. If a wetland is privately

owned, certain uses or construction would be permitted which have been shown not to be harmful.

In order to develop appropriate regulations or plans, the location of all Michigan wetland areas subject to the law must be known as well as those physical characteristics which affect decisions on their proper use and on protection against damaging construction and development. A major obstacle which will hamper the immediate development of such a comprehensive management program is the lack of adequate up-to-date, statewide wetland inventory coverage. Without this broad base of inventory data the state agencies involved will not be able to determine whether we are gaining or losing different types of wetlands and whether a given management strategy is proving effective.

The lack of data results from the fact that the state's past wetlands management approach was oriented towards individual projects. Thus, we now have only fragments of the broad data base which is required. In addition to being limited in extent, Michigan's available wetland resource information is also largely obsolete. The last statewide wetlands inventory occurred in 1955 and the usefulness of the data it produced is lessened for current purposes by the fact that it was collected using sampling. As a result, not much can be said about specific wetlands or geographical areas other than the sampling strata. A further limitation of existing data is that only state and federally owned land is considered, which constitutes only about 20 percent of the state's land area. The vast amount of privately-owned land representing some of the most productive and valuable wetlands is excluded. Furthermore, the public land holdings tend to be concentrated in the northern part of the state, while population is centered in the southern region making the remaining wetlands there, of which less is known, among the most valuable.

Although efforts have been initiated to remedy the situation (the wetlands bill, for instance), comprehensive management of wetlands in Michigan will be severely hampered for several years to come, unless a

means is found for obtaining the extensive basic wetlands inventory data that are required.

In order to assist DNR in carrying out its responsibilities for wetlands inventory, protection, and management, ERIM has undertaken a program to apply remote sensing technology to meet the information needs discussed above. This program was intended to provide an emerging field of resource management with the tools required to make it effective. The purpose of the program is to acquaint decision-makers with new information sources and resource inventory and analysis procedures to aid them in identifying appropriate strategies of wetlands management and the justification for wetlands preservation. The program was specifically designed to:

- Expose state, regional, and local decision-makers to the wetland inventory capabilities of remote sensing technology and provide them with criteria for selecting those techniques best suited for proposed statewide inventory requirements.
- Give wetlands management agencies the opportunity to test the usefulness of remote sensing information for policy formulation in on-going state management programs by furnishing them with a set of relevant inventory data.
- Document, in a technology user's guide, remote sensing techniques of proven value in wetland inventory work.

2.5.3 FEDERAL AND STATE WETLAND INVENTORY REQUIREMENTS

Within two years it is very likely that both federal and state wetlands inventories will be carried out in the State of Michigan. At the federal level, the National Wetlands Inventory (NWI) project being conducted by the Fish and Wildlife Service is entering its operational phase in late 1976, beginning with an inventory of the coastal zone states, of which Michigan is one. At the state level, Michigan will get the mandate to do its own wetlands inventory from the passage of the pending wetlands bill (HB 4618).

Because the funds available for both of these projects will be limited and the ability to perform the inventories in a short amount of time is critical to the effectiveness of both programs, both projects require using the most efficient, yet thorough, data acquisition and analysis techniques available. Some form of remote sensing is considered essential by nearly everyone involved. The questions that remain, then, are, "What is the best form of remote sensing to inventory wetlands and what survey strategy should be used?"

In answering these questions several factors must be considered. First, what is the purpose of the inventory? Developing a statewide wetlands management plan, for example, will probably require additional data beyond that obtained by the federal inventory, wich is more concerned with simply estimating wetlands abundance and location. Second, what type of data products are planned? The federal inventory intends to create a computer data base containing wetlands data for monitoring purposes; preparation of this computer data base need not be duplicated at the state level. Third, to what extent can the use of existing sources of remote sensing data result in cost savings? Michigan is fortunate in having a great deal of photo coverage, both small- and medium-scale, largely as a result of past NASA activity in the state. A great deal of SKYLAB photography and LANDSAT data are also available. The use of this existing data could cut the basic inventory data acquisition requirements for a wetland inventory in Michigan on a spatial basis by 50 percent. Other important factors could be mentioned, but this brief list illustrates the need for a well-thought-out analysis of the way in which remote sensing can best fulfill the needs of both user organizations.

Another group of users who should not be overlooked and who ultimately may prove most important are the local wetland managers. On a day-by-day basis these are the persons who implement policy and actually conduct management and protection activities. This group has many unique requirements for wetlands information which include even more detail and

frequent updating. In order to ensure that remote sensing makes the maximum impact on wetlands management, ways in which these local managers can use the results of any proposed inventory must also be addressed.

Because these three user groups represent most of the agencies and individuals directly concerned with the management of wetland resources for the public welfare, ERIM has taken the opportunity afforded by the NASA Grant to illustrate to these groups the effectiveness of remote sensing for assisting in wetlands management. For this purpose, we took advantage of wetland inventory projects undertaken by ERIM to satisfy specific information requirements. By documenting for these mission-oriented projects the techniques that have been used, costs, and results obtained, we have provided these organizations with the knowledge with which they can themselves design operational remote sensing projects in the future.

2.5.4 DISSEMINATION OF INFORMATION ON REMOTE SENSING

The objective of this task was to aid various groups in DNR in identifying the most effective remote sensing techniques for their purposes. The stimulus for this aspect of ERIM's program is to ensure that the optimum remote sensing technique is selected for use in the proposed statewide wetlands inventory and to provide guidelines for the use of remote sensing in the every day management of wetlands.

We chose to accomplish this by providing the potential user with a technical basis for a comparative evaluation of the wetlands mapping capabilities of remote sensing by summarizing what has already been learned about how to accomplish this type of work, and the results that have been achieved. In practice we have disseminated this information by three methods: (1) participating in workshops with users; (2) presentations at user conferences; and (3) publishing a technical report entitled "Remote Sensing of Wetlands." We found that for maximum clarity the information should be organized into five basic subject areas: (1) remote sensing systems; (2) data collection; (3) data reduction;

(4) analysis; and (5) cost-effectiveness.

Remote Sensing Systems. Three types of sensor systems were recommended as having reached an operational status for remote sensing of wetlands: photography, multispectral scanning, and radar. Each of these sensor systems was described in terms of how it works, unique information/extraction capabilities, technological risk, and user availability. The information detectable by each sensor system was related to the information used in various wetland classification systems so that the best match-ups could be identified. The influence of the data collection platform on data usefulness and information content was also explored, particularly for aircraft and orbiting spacecraft.

Data Collection. Whether existing data or new data are used to perform a wetlands inventory, information extraction can be optimized by taking advantage of several factors related to the process of data collection. Each of these factors was reviewed and recommendations were made for using them in connection with any one of the three sensor systems mentioned above.

For example, three types of factors were found to be of importance to photography: environmental factors; photo-sensitive materials; and cameras and lenses. To illustrate the range of topics reviewed which relate to collecting good remote sensing data, environmental factors discussed include illumination, haze, sun angle, spectral reflectivity of objects, and vegetation phenology.

Data Reduction. Topics of interest that were covered under data reduction included a review of the fundamentals of photointerpretation and various types of automated vs. manual modes of multispectral scanner data processing. Both multispectral scanner (MSS) and radar data reduction was further investigated by providing reviews of selected wetland inventory demonstration projects. The complexity of the data

reduction task was considered in all cases as well as the need for specialized equipment. Costs for various forms of specialized data manipulation were also presented.

Analysis. In addition to showing how remote sensing can assist field survey techniques in conventional analysis procedures, several ways have been pointed out in which remote sensing provides either a unique analysis capability or a highly efficient automated means of doing tasks that before now were little used because of the enormous human effort required. One example of a unique capability is the use of data derived from historical remote sensing, compared with current information, to develop trend analysis and change detection. As an example of task automation, area and boundary statistics can be generated by computer from digital data in negligible time compared to the time consumed by manual planimetry.

Cost-Effectiveness. This subject was examined from several standpoints: timeliness, type of wetlands information, variety of wetlands information, and cost per sq. km. Any one or all of these factors may determine the viability of remote sensing in a given wetlands inventory project. It was emphasized that in figuring costs, more should be included than just data collection and processing. Analysis, data base maintenance, and results dissemination are important items that determine the usefulness of an inventory and their costs must also be accounted for.

ERIM staff participated in two workshops:

Michigan DNR National Wetlands Inventory Pre-workshop Meeting, 17 July 1975, Lansing, Michigan

National Wetland Classification and Inventory Workshop
U.S. Fish and Wildlife Service
July 20-23, 1975, Washington, D.C.

The following presentations were made at user conferences:

14 November 1975	"Quantitative Analysis of Wetlands Using Sequential Remote Sensing Data", Norman E.G. Roller, AIAA Symposium "Applications of Remotely Sensed Data in North Central United States", Bendix Aerospace Systems Division, Ann Arbor, Michigan.
7-10 December 1975	"Quantitative Analysis of Deer and Waterfowl Habitat Quality and Trends Using Sequential Airphotos", Norman E.G. Roller, 37th Midwest Fish and Wildlife Conference, Toronto, Ontario, Canada.
3 June 1976	"Natural Vegetation Inventories", Norman E.G. Roller, North American Assembly of International Association for Vegetation Sciences, Ann Arbor, Michigan.

ERIM publications on remote sensing of wetlands include:

July 1975	Tentative Classification of Lifeforms and Subforms of Common Michigan Wetland Vegetation. Norman E.G. Roller, Environmental Research Institute of Michigan, Report No. 193400-12-I.
September 1975	Changes in the Wetlands and Land-Use Patterns of St. John's Marsh, St. Clair County, Michigan. Norman E.G. Roller, Environmental Research Institute of Michigan, Report No. 193400-11-I.
(In Press)	Remote Sensing of Wetlands. Norman E.G. Roller Environmental Research Institute of Michigan, Report No. 193400-14-T. Ann Arbor, Michigan.

The report "Remote Sensing of Wetlands" has been written for the professional biologist or land use planner who manages or advises in the management of wetlands. It explains the application of remote

sensing techniques to wetland inventory information requirements. The material covered is that described at the beginning of Section 2.5.4. Many of the prominent examples of remote sensing projects are surveys funded by the NASA Grant in previous years, such as the vegetation inventory of Pointe Mouillee. Also discussed are results of the LANDSAT and SKYLAB programs. After publication, this report will be widely distributed to Michigan agencies responsible for wetland management.

2.5.5 STATEWIDE WETLANDS INVENTORY PLANNING ASSISTANCE

Once the state wetlands bill (HB 4618) is passed (possibly in September 1976) DNR will be requested to conduct a statewide survey of Michigan's wetland resources within 18 months. DNR staff members have stated that if traditional field survey techniques were to be used, a special project funding appropriation on a very large order must be provided, which is unlikely. There are ways to produce a useful inventory for a reasonable cost using remote sensing, and ERIM is working closely with DNR to evaluate this alternative strategy.

The interest in conducting natural resource and land use inventories in Michigan is widespread. Several agencies and groups are currently in the planning stages of this type of work to meet assigned responsibilities:

- Fish and Wildlife Service (U.S. Department of Interior): National Wetlands Inventory, to begin in 1976;
- Forest Service (U.S. Department of Agriculture): Timber Trends Inventory;
- Forest Division, DNR: Federally funded periodic timber inventory project;
- Land Use Programs Division, DNR: Coastal Zone Management and Section 208 land use inventories;
- Wildlife Division, DNR: state wetlands inventory;
- Private forest industry: timber appraisal and sales.

Thus several agencies have inventory mandates, requirements and funding to perform resource inventories in Michigan. ERIM is cooperating with these agencies to develop a plan for a single, comprehensive, jointly-funded inventory project that will avoid needless duplication of effort, and at the same time provide each agency with the information it needs. By collecting only one set of data and spreading the costs among the users, each group will be able to devote more of its resources to the analysis of the data for its specific purposes.

Meetings are currently being held to define the funding picture in more detail and to specify the photo data collection parameters in preparation for seeking contract bids. Anticipated cost for 1:24,000 color photo coverage of the entire state is estimated to be around $350,000. ERIM is currently involved in discussions on film scale and film type, and data acquisition costs. Structure of the interpretation task is also being considered. Copies of the report "Remote Sensing of Wetlands" will be distributed to representatives of all the interested agencies and companies to provide a factual basis for decisions on these and other matters.

2.5.6 DEMONSTRATION OF MANAGEMENT POLICY ANALYSIS

The long term impact of any inventory-derived information, whether obtained by remote sensing or by field crews, is basically a function of how it influences management policy. Thus, showing how remote sensing can furnish the information needed for policy formulation was considered an essential aspect of our program. The thrust of our effort in this part of the program differed from that of the inventory technique demonstration work in that here we emphasized the analysis of raw inventory data for the purpose of generating information.

To ensure that wetlands management policy-making users at the state level fully realize the value of remote sensing to their work, the analysis techniques ERIM felt were most appropriate for their use and

adoption were used in a demonstration project to obtain quantitative data describing wetland condition as a function of changing land use and environmental conditions. We were assured by the interested agencies the data would be used because the specific area jointly chosen for analysis, St. Clair Flats, is one of the most environmentally sensitive and topical areas in the state. We have also made it a point to disseminate this information throughout the DNR as widely as possible, particularly encouraging its use by committees made up of members from a variety of the individual management branches within DNR. In this way the future use of remote sensing by the largest number of groups is promoted, and the possible cooperation of several groups in comprehensive remote sensing inventories becomes a real possibility.

The wetlands along Anchor Bay in Lake St. Clair were selected as the site of a demonstration wetlands inventory for two reasons: (1) the state needed a test of the wetlands section of the new Michigan land cover/use classification system adopted in November 1974, and (2) a common basis for comparison of various types of wetland remote sensing data was needed.

The St. Clair Flats are among the best known of Michigan's wetlands. The area is composed of two large islands and many smaller ones forming the delta of the St. Clair River. Harsens and Dickinson Islands are the largest and have been subject to flooding and wave-action damage from high water levels in Lake St. Clair in recent years. The southern part of Harsens Island is a state managed wildlife refuge and waterfowl hunting area.

In the 15 year period from 1952 to 1967 building on the wetlands surrounding Lake St. Clair increased over 100 percent. There was an increase of over 200 homes on Harsens Island alone. This pattern of unwise dredge, fill, and construction has continued up to the present. As a basis for denying permits for future wetland destruction, planning acquisition of valuable areas and establishing a regulated urban growth and use policy, current wetlands inventory data is considered essential.

ERIM, under sponsorship of the NASA Grant, has provided many of the agencies involved, such as the Wildlife Division and Land Use Programs Division of DNR, with the information needed to develop a new land management policy for the area featuring greater wetlands protection. As implemented, the project consisted of a photointerpretation inventory of some 93 sq. km of delta islands and Lake St. Clair shoreline as far west as New Baltimore (see Figure 3). The baseline photography used consisted of Michigan shoreline photography (color, 1:10,000) collected by ERIM on 10 April 1974 and NASA U-2 photography (CIR, 1:120,000) collected on 29 June 1975. The cover type mapping system used was the Michigan Land Cover/Use Classification System developed by the Land Use Programs Division. The project products consisted of manuscript maps at 1:20,000 coded with 4-digit land cover/use codes. These maps have been sent to the Land Use Programs Division where they have been copied and are now available to all interested users. Specific applications of this data relating to decisions on extension of leasing rights are discussed in Section 2.3.

3
SAND AND GRAVEL MINING

Michigan is the nation's second largest sand and gravel producing state, in terms of dollar value. Sand and gravel ranks fifth, by value, in Michigan's mineral production (surpassed by iron ore, cement, salines, and copper). In 1973 (the latest year for which data were available), the value of Michigan sand and gravel production was in excess of $75 million. There are 360 sand and gravel companies operating in Michigan. Some sand and gravel is produced in every county in the state [6]! Lake Michigan shoreline sand dunes are of particular significance as a source of high quality industrial sands important to the foundries that service Michigan's number one industry, the automobile industry. Some of the largest, purest, and most readily accessible deposits of industrial sand are located in dunes areas along the Lake Michigan shoreline [7].

3.1 ENVIRONMENTAL ISSUES

Many of these areas have scenic, recreational, and environmental values entirely apart from their content of a mineable resource. But the dunes are a non-renewable resource. When they are gone, they're gone--taking with them many of the scenic values that make the shoreline areas both desirable places to live and competitive with other areas as a destination for tourism; and tourism is the state's second most important industry. Therefore, the long-term general loss of the scenic and recreational values must be balanced against the short-term immediate economic gain to be derived from dune mining.

ERIM undertook the task of applying remote sensing data in support of the West Michigan Shoreline Regional Development Commission (WMSRDC) and the West Michigan Environmental Action Council (WMEAC) in their attempt to induce local zoning actions and state legislation to protect recreational and environmental areas against damage from sand and gravel

mining operations. Remote sensing data were used to assist in publicizing the need for passage of a sand dune mining bill. ERIM has also proposed the use of remote sensing as an effective method of monitoring sand and gravel mining operations once state laws have been enacted.

Because of the importance of sand and gravel for highway construction, the Michigan Department of State Highways and Transportation (MDSH&T) maintains information pertaining to construction of sand and gravel operations in the state. The Department has compiled an Aggregate Source Inventory [8] which is periodically updated by means of a questionnaire mailed to operators. Analysis of this inventory indicates that there are more than 700 abandoned sand and gravel operations in the state.

3.2 ENACTMENT OF LEGISLATION

The Sand Dune Protection Law was introduced to the State Legislature early in 1975. After many conferences with sand mining interests, environmental groups, and local residents and businesses affected by sand mining operations, a revised bill was agreed to, and in November of 1975 passed the House of Representatives by a 96-7 margin. The bill was stalled in the Senate for more than 30 weeks by an unfriendly committee chairman, but was finally reported out of committee on 1 July 1976, and passed the Senate on 9 July. This bill contains requirements for state permits and Environmental Impact Statements and provisions for collection of surveillance fees.

A second bill (SB 852) introduced to the legislature, would regulate construction sand and gravel extraction activities and reclamation. This bill has had no active attention thus far in the current legislature.

The Department of Natural Resources (DNR) Geology Division has recently been working on revision or amendment of the state Mining Act with the purpose of strengthening environmental protection and

reclamation provisions. The revised version will include all open pit or surface mining; sand and gravel extraction as well as rock quarrying, copper, iron ore, coal mining, etc.

As in the case of the recently enacted Sand Dune Mining Bill, other proposed surface mining legislation can be expected to designate the state Department of Natural Resources as the administrative and regulatory agency, and to exempt existing extraction operations from provisions of new legislation. It is evident that Geological Survey Division of the DNR will need all new tools possible to inventory and monitor dune mining, sand and gravel extraction and other surface mining operations.

Under this project, ERIM personnel were in contact with the West Michigan Shoreline Regional Development Commission (WMSRDC) and the West Michigan Environmental Action Council (WMEAC). The WMSRDC is an established regional planning agency; WMEAC is a coalition of citizen environmental groups. These two groups were concerned about sand dune mining operations in the area and were the prime movers in expediting passage of the state Sand Dune Mining Bill. As part of a citizen/ legislator education effort the WMEAC prepared an information brochure, Sand Dune Mining and the two groups collaborated to assemble a slide show. The slide show was made available to civic groups (e.g., Kiwanis, Church, school, Boy Scouts, and fraternal organizations) and was shown to as many local and state officials as could be enjoined to see it. ERIM provided several high altitude color IR aerial photos to help illustrate the distribution of mineable sand dunes in the area. The slide show used hand-held oblique photography to illustrate the size of operations, good and bad reclamation activities, etc. ERIM suggested acquisition of sequential photography from ASCS to illustrate before, during, and after mining. Prior to completion of identification and ordering of this photography the Sand Dune Mining legislation was passed by the State House of Representa-

tives with every indication that it would have no trouble in the Senate. Being occupied with numerous other pressing issues, WMEAC elected not to further pursue the dune minning photography.

3.3 ADDITIONAL REGULATION REQUIREMENTS

Passage of the Sand Dune Mining bill represents one major step forward, but the problem of regulating extraction of construction sands and gravel remains unsolved. Throughout the state, but especially in urban areas, citizens and government entities are becoming increasingly concerned about extractive operations. As the population grows and urbanization spreads, the demand for sand and gravel increases and competition for the land intensifies. Sand and gravel operations are aesthetically obnoxious; their proliferation needs to be controlled and their operations regulated.

The aggregate "lobby" is powerful in Michigan. The industry has managed to remain exempt from regulation under the Surface Mining Act and under the Soil Erosion and Sedimentation Act. Passage of state legislation is undoubtedly inevitable, but will come about only after a long hard battle. In the meantime many county government units, especially the Planning Commissions, are searching for an effective means to regulate extractive industries.

A Washtenaw County Metropolitan Planning Commission memo dated May 10, 1976 noted that:

> "The location and regulation of extractive operations has historically been a major issue among township governments within the County. By nature, extractive operations can cause many nuisances and problems such as truck travel, noise, dust, unsightliness, irregular working hours, etc. In addition, the played out gravel pits, especially those older operations where reclamation planning is not carried out, can cause severe problems in determining future use and also create ongoing safety problems....

"There appear to be three basic approaches in regulating gravel pits: (1) placing extractive operations as a conditional use in certain zoning districts; (2) creating an exclusive district for extractive operations; and (3) establishing a nuisance ordinance. The first approach is presently being utilized by all twenty townships within Washtenaw County."

The Planning Commission hopes to encourage townships to implement the third approach, i.e., adopt a nuisance ordinance. One of the major problems concerning gravel pits has to do with operations which were in existence prior to establishment of a zoning ordinance and are thus nonconforming. By having a separate nuisance ordinance, outside of the zoning ordinance, it is possible to provide regulations to existing operations. It is also possible to have more extensive type regulations which may not be permissible under zoning powers.

Several townships have had recent requests for permits to expand existing operations or to open new pits. Recognizing that they have a common problem, an informal ad hoc committee of concerned representatives from these townships recently met to discuss the issue. Plans were made to formalize the committee and extend invitations to participate to all townships in the county. This committee will work with the Township Planning Commissions and the County Planning Commission to draft a model nuisance ordinance that could be adopted by all townships.

A representative from ERIM was invited to attend a Planning Commission meeting to discuss the sand and gravel problem, and attended the informal committee meeting of township representatives. Both groups indicated an interest in cooperating with ERIM in an effort to use remote sensing data both to identify sand and gravel deposits in the county and to monitor extraction operations.

It is anticipated that by working at the township/county level throughout the state, sufficient interest will be aroused so that state legislation can become a reality.

4

SOIL EROSION AND SEDIMENTATION

4.1 EXISTING LEGISLATION

Michigan's Soil Erosion and Sedimentation Act of 1972 (PA-347) was enacted to "provide for the control of soil erosion and to protect the waters of the state from sedimentation..." It is an important factor in statewide efforts to improve water quality. The law applies to all "earth change" activities connected with construction projects which disturb more than 1 acre of land or if the earth change is within 500 feet of a lake or stream. Earth change activities may be associated with transportation facilities, subdivision, industrial, or commercial development, recreational facilities, water impoundments, and waterway construction. Mining and logging are exempt, and the rules for implementation will not apply to agricultural practices until 1 January 1979.

The Act and the promulgated rules establish a rather complicated enforcement structure. Administration and enforcement have been delegated to the counties. That is, the county Board of Commissioners designates the enforcement agency. That agency may be the county road commission, county drain commission, building inspection division, or some other agency. However, any city, village or charter township may develop its own local control ordinance and enforce it locally. Such a local ordinance and implementing program must be approved by the Michigan Water Resources Commission. Certain authorized public agencies (APA s) become exempt from obtaining local permits by submitting their own soil erosion and sedimentation control program to the local soil conservation district for review and finally to the Water Resources Commission for approval. The local enforcing agency, with the assistance of the Commission, then becomes the enforcing agency responsible for policing the agency's earth changing activities. Furthermore, all

state agencies who undertake any earth changing activities are subject to the law and must develop approval programs. State Agencies that now are APA s are:

Department of State Highways and Transportation (MDSH&T)
Department of Natural Resources (DNR)
Department of Agriculture
Waterways Commission
Michigan State University (MSU)

4.2 ENFORCEMENT ACTION IN WASHTENAW COUNTY

Washtenaw County Soil Erosion and Sedimentation regulations were approved in December 1974; therefore, the County has had a program since the rules took effect on 1 January 1975. The County Building Inspection Department is the local enforcing agency. The physical inspection of sites is done by a member of a private engineering firm, under contract to the Building Inspection Department. The Washtenaw County Road Commission and the Washtenaw County Drain Commission are Authorized Public Agencies (APAs) under the Act. Pittsfield Township, the cities of Saline and Ann Arbor are Local Enforcing Agencies (LEAs).

Local public interest groups in Washtenaw County who are concerned with assisting the state and local governments in monitoring earth change activity and following up on apparent violations of the law include the Sierra Club, the Ann Arbor Ecology Center, and the University of Michigan Environmental Law Society.

In January 1976 the local group of the Sierra Club was alerted to an apparent Soil Erosion and Sedimentation Act violation, and became involved in actions to require compliance with the law. Part of this action was to request aid from ERIM in the form of imagery that could be used to document the erosion problem.

In this case, an aggregate company was in violation of PA-347. In the process of extracting sand and gravel, the company was operating

within 500 feet of the Huron River. Large spoil or overburden piles, or retaining walls parallel the river for a considerable distance. Soil erosion on these piles was excessive and had contributed to considerable sedimentation in the Huron River. Requests for enforcement action were made to the local enforcing agency. When no mitigating measures were evident after a reasonable length of time, the issue was taken to the State enforcing agency, the DNR. At the same time the Sierra Club was documenting the violation with ground photography and asked ERIM to help by providing aerial photos or other remote sensing data that could document the violation. The DNR enforcing agent visited the site, established that there was, indeed, a violation and informed the operator of the corrective measures required to bring the operation into compliance.

As the issue now stands, the gravel pit operator has initiated the corrective measures as advised, and local environmentalists continue to monitor the site to assure that the measures are effective.

Experience with this specific issue has alerted environmentally concerned citizens to the less-than-rigorous implementation of PA-347. A plan is underway to screen currently active permits issued under PA-347 rules, and to monitor the activities, with the hope of contributing to more effective enforcement of the Act.

ERIM has discussed with members of the local citizen groups the utility of remote sensing data as a means of monitoring earth change activities, documenting violations of the Act, and enforcing compliance with the law. Accordingly these groups have requested continuing aid from ERIM to learn how to most effectively use remote sensing data in these tasks. ERIM staff members will continue to work closely with both public interest groups and state and local enforcement agencies to apply effective methods to accomplish these functions in specific cases.

5

REGIONAL RESOURCE MANAGEMENT

Regional planning and development commissions, while not acting as decision making bodies, are in the vital position of acting as resource centers for economic, social, and environmental planning and development. This pivotal role makes them a logical choice for initiating and coordinating remote sensing programs for their respective regional areas. Making these centers self-sufficient as remote sensing resource centers can be facilitated by the availability of up-to-date imagery and training in its use. They can then make effective use of data available to them in meeting their mandated responsibility and in acting as informed consultants to both the public and the private sector.

Previous experience with the introduction and use of remote sensing technology in the Upper Peninsula of Michigan was reported in Reference 1. The general procedures for introducing the technology were found to be highly successful. Recent contacts with Upper Peninsula agencies who were involved in that program indicate that remote sensing data and techniques continue to be extensively used for a wide variety of applications throughout the area. Thus, any extension to a new region should be patterned after that program.

5.1 GRANT ACTIVITY

Based on this previous experience with regional commissions, the project initiated a program of technical assistance in remote sensing with the East Central Michigan Planning and Development Regional Commission, located in Essexville, Bay County. Initial interest of the commission leaders was developed through presentation and discussion of relevant grant activities from previous years. Having whetted their appetite, ERIM planned a high altitude aircraft photographic mission

over the area. This mission was approved by NASA and flown on 29 July 1975. Due to delays in delivery of the film from NASA, it was not presented to the regional staff until late October. A training workshop was then conducted for regional staff members, encompassing the basic elements of interpretation and data extraction from the color-IR imagery. Since January 1976 and continuing through the present, the regional commission staff made intensive use of the imagery for numerous on-going projects. In addition, various local agencies within the region expressed a high degree of interest in the imagery. For this reason, a presentation workshop for representatives of the local governments and agencies was held in April at the regional commission offices. At this meeting, the desire of the local agencies to acquire specific images of interest, and to develop a system for better utilization of the imagery at the regional commission office was expressed. Toward this end, ERIM has offered guidance to the regional staff regarding equipment, supplies and set-up in order to make the imagery readily accessible and usable. ERIM has also assisted several local agencies to utilize the imagery to address specific problems.

5.2 RESULTS

The East Central Michigan Planning and Development Region has in the last year become a full time user of remote sensing imagery. They are now incorporating the imagery provided through the grant activity, as well as other available photography, into all of their relevant activities.

The high altitude imagery has been used to augment the region's Coastal Zone Management (CZM) Program. Specifically, environmental areas (mostly marsh and wetlands) have been delineated and evaluated. By comparison of the new imagery with historic photography, wetlands and other shore areas lost to erosion have been mapped. Also, the

imagery will allow the region to create a detailed land use map of the shore zone, a prerequisite for implementation of the management plan to be created under the state CZM program.

The imagery is also being used in the public debate over the CZM management plan. Local citizens and agencies are using the imagery to prepare their arguments in disagreement with the designation of certain shoreline areas for special protection. In some cases, it is felt that too much land is being put under restrictive use for environmental purposes, while in others, it is felt that not enough area has been included. We anticipate that the NASA-provided imagery will play an important role in the final decisions concerning many such areas. For instance, the Arenac County Equalization Department, in cooperation with land owners convinced the Michigan Department of Natural Resources (the agency administering the CZM program) that parts of a wetland area near Standish which had been designated for total exclusion of human development, had in fact been agriculturally productive areas in the past. The imagery clearly showed evidence of these past practices, in the form of dikes and latent plow marks. With this evidence in hand, the designation of the area was changed to allow further intensive agricultural development in those areas previously cultivated.

The imagery has also been supplied by the regional commission to the engineering firm tasked under contract to plan the siting of sewage treatment plants. In this instance, the high altitude photography was useful in identifying potential locations for such plants. More detailed, low altitude photography was required for the detailed facility planning, however; so the final determinations of specific facility sites has yet to be made.

The 1975 high altitude imagery also served an extremely important function as "ground truth" information for LANDSAT mapping of the entire 20,000 sq. km region. This land cover/use mapping project was carried out to provide basic data for the region's Section 208

Areawide Wastewater Management Program. While the computer processed LANDSAT data were used to map the land resources over the entire extensive area, the aerial photography proved to be invaluable as an aid in identifying and delineating training sets for the computer processing, and in verifying and modifying classifications. Without it, the modest accuracy achieved by the LANDSAT processing could have been seriously degraded. In addition, the aerial photography was used to supplement the LANDSAT information in critical areas, providing a level of detail, and especially accuracy, of information impossible from the satellite data. The combined land cover data base is now being used to develop the required management plan to maintain or improve the surface water quality of the region.

5.3 ANTICIPATED USE

As is evident from the examples cited above, NASA-supplied remote sensing products are now playing a major role in the activities of the East Central Michigan Planning and Development Region. A responsive audience at both the regional and local levels has been reached, and identifiable products and results of this introduction of a new technology are being achieved. Continued use of existing remote sensing imagery for many varied purposes, and expanded acceptance of the technology, leading to ongoing data collection and analysis programs, are expected.

6

THERMAL EFFLUENTS IN THE SOO HARBOR

Concerns have been expressed in public hearings on the effects of thermal effluents in the Soo Harbor area near the Soo Locks. During the winter, these effluents may have the effect of melting ice and detaching it from the shoreline, allowing the ice to flow into the Little Rapids Cut downstream of the harbor. The resulting ice jam interferes with the operation of the local ferry and causes flooding of surrounding land areas.

The Detroit District of the Corps of Engineers has responded to these concerns by trying to locate point sources of effluent and determine their dispersal patterns into the St. Mary's River. As one source of information, the Corps purchased from ERIM thermal imagery collected during the Michigan shoreline flight program of April and May 1974 under the NASA Grant. ERIM supplied this imagery along with an interpretation of the thermal effects observable in the imagery.

Aerial thermal data of the Soo Harbor and St. Mary's River were collected at 3 PM on 7 May 1974. These data were collected by ERIM for the NASA Office of University Affairs as part of a flight program wherein 70 percent of the shoreline of the State of Michigan was recorded. The 2,400 m aircraft altitude resulted in an image resolution of approximately 7.2 m. The temperature-calibrated 9.0-11.4 μm waveband was recorded on digital magnetic tape.

To meet the request of the Corps, the thermal imagery was played back at high gain on the cathode ray tube of a filmstrip printer and photographed. The video levels were set to enhance slight temperature differences associated with the surface water in preference to showing land temperature variations. In other words, while the original data accurately recorded surface temperatures over a large temperature range, which includes warm land and cold water, only the cold water range is

depicted in the images supplied the Corps. All land areas, which were warmed by solar heating, appear uniformly white. Image grey tones show primarily locational differences in surface water temperature. These differences are only several degrees.

Figure 8 shows the St. Mary's River from the Soo Locks to the south end of Sugar Island, a distance of roughly 5.5 km. While this image shows some subtle contrasts associated with different surface water temperatures, no marked temperature differences occur over most of this portion of the river. In particular, the hydroelectric power plant at the end of the canal does not cause observable higher water temperatures at the outfall. The image shows several locations of possible outlets resulting in slightly warmer surface water temperatures. Shallower water near protected shore areas tend to appear slightly warmer than main channel locations. It is suggested that the swift and turbulent flow of the river quickly distributes and dissipates slight near-surface temperature contrasts associated with outfalls. A warm boat is seen at the power house outfall.

Figure 9 shows the Soo Locks area. This thermal image, obtained 2 minutes after the previous image shows the "warm" boat 300 m further down river. In the river above the locks the nearshore areas show some temperature patterns related to currents. For example a large counter-clockwise spiral appears above the locks.

The thermal imagery does indicate possible sources of thermal effluent, so that study can be concentrated on these sources and methods devised to minimize the destabilizing effect of the effluents on ice. For example, it might be possible to direct the effluent away from the shoreline and into the shipping track in the center of the channel.

The use of thermal effluents to make possible year-round navigation of the Great Lakes is also of interest to the Corps. Directing the thermal effluents away from the shoreline would have the beneficial effect of melting ice in the shipping track.

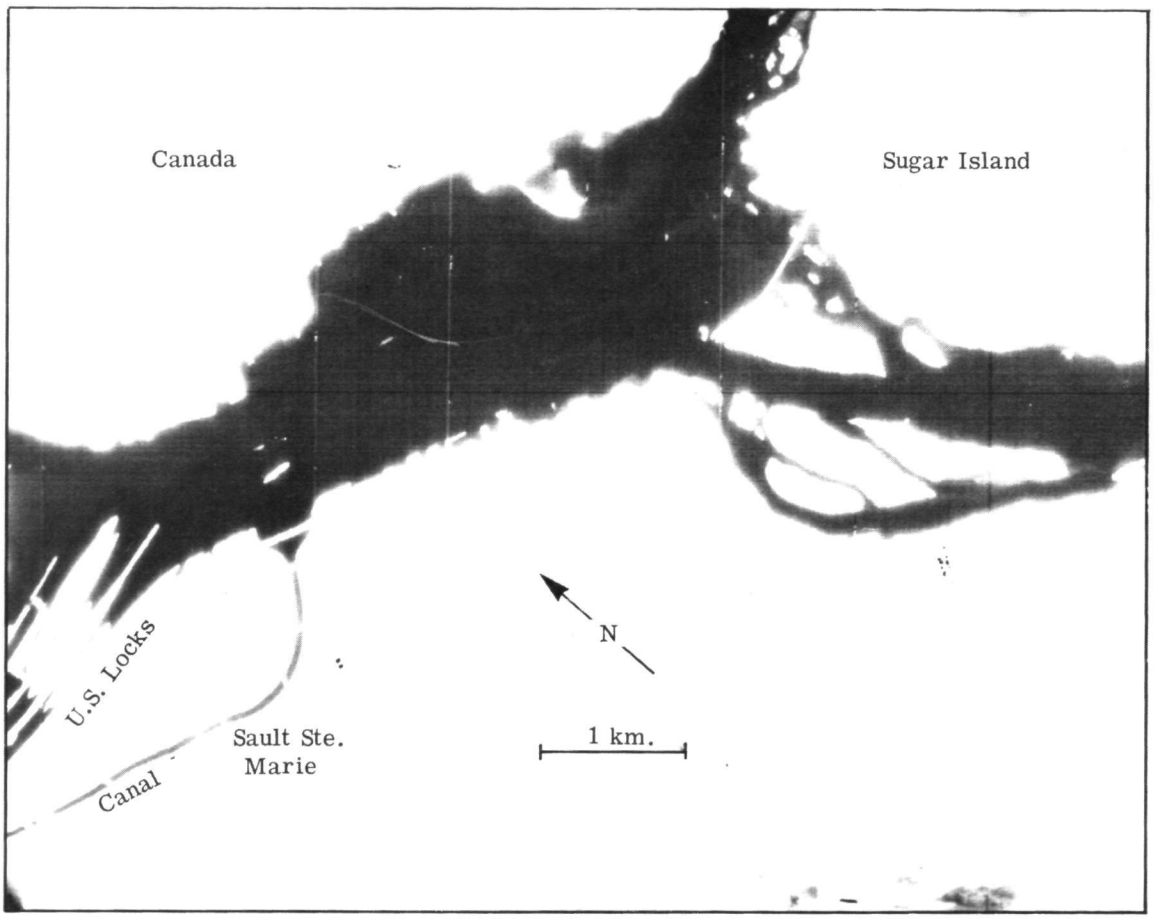


FIGURE 8. THERMAL MAP OF ST. MARY'S RIVER

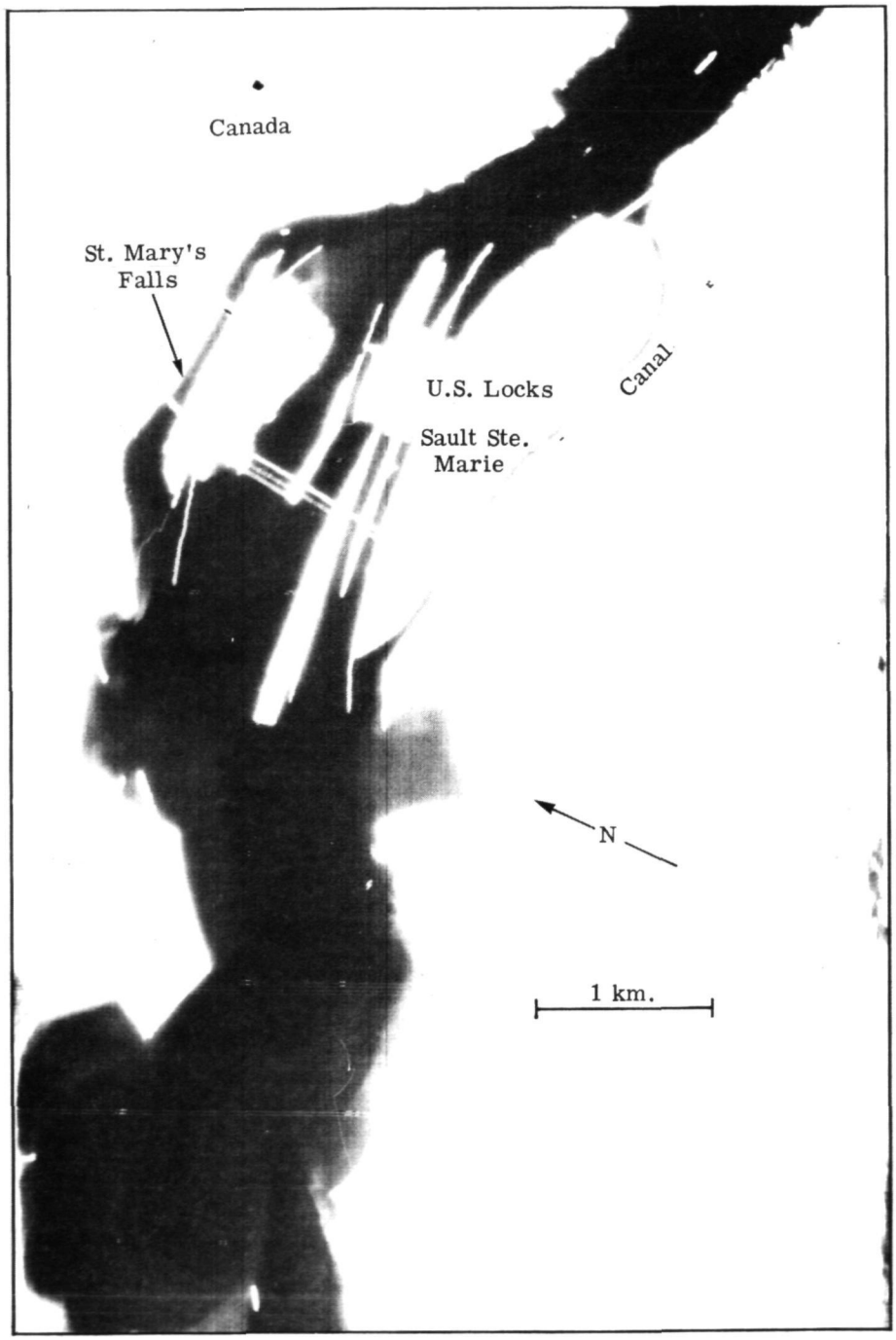


FIGURE 9. THERMAL MAP OF SOO LOCKS

Thus, the Corps of Engineers has a continuing interest in this application of thermal imagery. Study of the thermal imagery supplied from the Michigan shoreline flights has led to an improved understanding of the potential use of the imagery for studies of ice cover.

The data supplied to the Corps was not acquired under optimum conditions of season, altitude, or temperature range for the specific application. The high altitude and large recorded temperature range in some respects reduced the quality of these data for detection and charting of flight thermal patterns in the St. Mary's River. However, the data are calibrated and precise surface temperatures can be obtained from further processing. Under optimal conditions, data could be collected at a higher spatial resolution and a smaller temperature range. In addition to airborne techniques, portable hand-held infrared scanners can be used on the ground or from a helicopter to image the patterns of thermal effluents in real time.

7

FRESH GRAVE DETECTION

In the field of crime detection, the problem of locating fresh shallow graves is an urgent matter, even though the need arises only occasionally. ERIM has received inquiries from law enforcement agencies on this subject from time to time, but has never become actively involved because of the lack of detailed knowledge concerning the implementation of remote sensing methods. Our previous research on the use of thermal detection for shallow buried objects indicates that fresh shallow burials are usually thermally detectable, but the question always arises as to whether these changes are sufficiently significant and predictable to permit reasonable detection probability within acceptable false alarm rates.

It would be of distinct value to law enforcement agencies to be able to detect fresh graves by thermal methods, and to understand the circumstances under which these methods can be successfully applied, as well as the equipment and procedures for applying them. Fortunately, it is possible at a small expenditure of effort to provide this basic information, which would be a significant contribution in itself. Also, a capability for undertaking a search on short notice would represent an important addition to the ability of local law enforcement agencies to conduct criminal investigations. This type of application obviously cannot be planned or scheduled in advance, but a standby capability on the part of ERIM would be of substantial value. If this type of application were called for, ERIM could then respond, with the possibility of making a major and newsworthy contribution to the solution of a criminal case.

To prepare ourselves for future requests (which will be actively solicited), ERIM conducted under the NASA grant a small field study to demonstrate the detection of buried bodies. The results of this filed investigation and conclusions as to operational feasibility will be

summarized and presented to local law enforcement agencies so that they are in a position to select this method where circumstances justify its use. Preliminary results of the field study have been obtained during the present reporting period and are documented in this section. These preliminary results are very encouraging.

Changes in soil characteristics that result from removing and replacing the soil modify the thermal characteristics of the soil. These effects are due to differences of soil compaction with accompanying changes in soil moisture retention. These changes affect both the thermal conductivity and thermal capacity of the soil. Existing thermal models indicate that as a result, the thermal response to solor insulation and ambient air temperature changes will differ for the original soil and the disturbed soil, making it possible to detect disturbed areas. Thus, atmospheric conditions are very important in determining the feasibility of detecting buried bodies and were the predominant parameter in demonstrating detection capabilities.

Parameters which must be considered in determining the optimum time to look for signature differences include amount of and time duration since last rainfall, season, time of day, cloud cover, and the terrain features of the area to be investigated. While a parametric study to determine optimum conditions has not been conducted, preliminary analysis indicates that the largest signature difference should occur a few days after a rainfall, during clear conditions, and at either the extremes of temperature (∿3:00 PM or 4:00 AM) or the maximum rate of temperature change (∿9:00 PM or 9:00 AM). These times will change depending on the season of the year.

Rather than conduct an expensive remote sensing investigation of this phenomenon which is beyond the scope of the Grant program, a preliminary study was conducted utilizing a portable ground-base infrared imaging system (AGA Model 750 Thermovision). A local cemetery containing only surface gravestones was selected for the initial investigation in order to reduce thermal anomalies due to shadows.

The first field trip was made on 11 May 1976 at 3:30 PM. This was a partly cloudy day with the air temperature at 10°C (50°F) and wind speed of 24 km per hr. Three graves were inspected of varying ages (four months to three years) and were not thermally observable.

A second field trip was made on 12 May 1976 at 9:00 PM with markedly different results. This was a clear night with an air temperature of 13°C (55°F) and wind speed of less than 8 km per hr. All graves inspected at this time were thermally observable. Figure 10 is a visible picture of the first grave site visited and Figure 11 is a thermograph of the same area. The small steel rod marks the top center of the area that has been disturbed. The grave area is noticeably cooler than the surrounding grass while the bare soil areas are the warmest areas in the scene. This grave was nine months old at the time of the field strip.

The second grave site visited is shown visually in Figure 12 and thermally in Figure 13. The grave area was easily detectable, although the detected area in the polaroid picture is not as apparent as it was on the thermovision display. In general, the contrast between the grave area and the surrounding area later in the evening (~10:30 PM) was not as clear as it was earlier in the evening. This second grave site was approximately two years old.

The third grave site visited during the field trip was located next to a tree, unlike the previous two areas which were in open areas. This area is shown in the photograph of Figure 14 and the thermovision image is shown in Figure 15. This grave was 4 months old at the time of the field trip. Again the grave area was readily detectable, although the polaroid picture does not clearly demonstrate the observed contrast.

The results just discussed are sufficiently encouraging to justify continued refinement of the application. Further consideration is now being given to the applicability of an airborne platform for obtaining

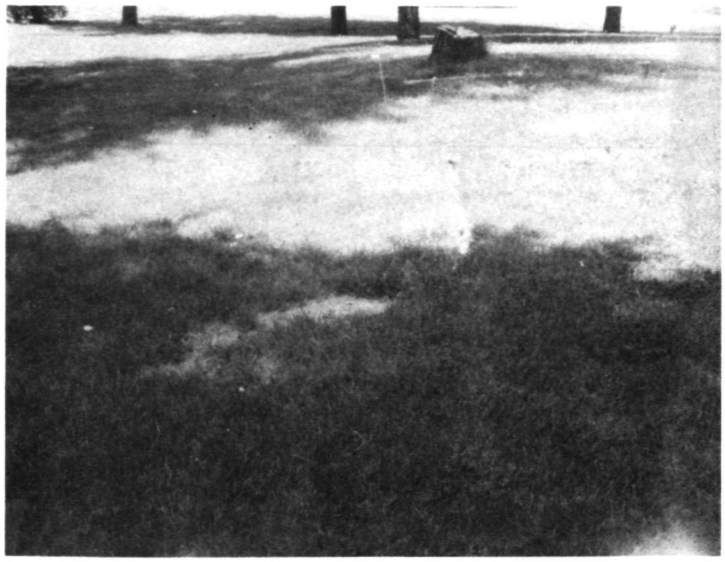


FIGURE 10. NINE MONTH OLD GRAVE AREA

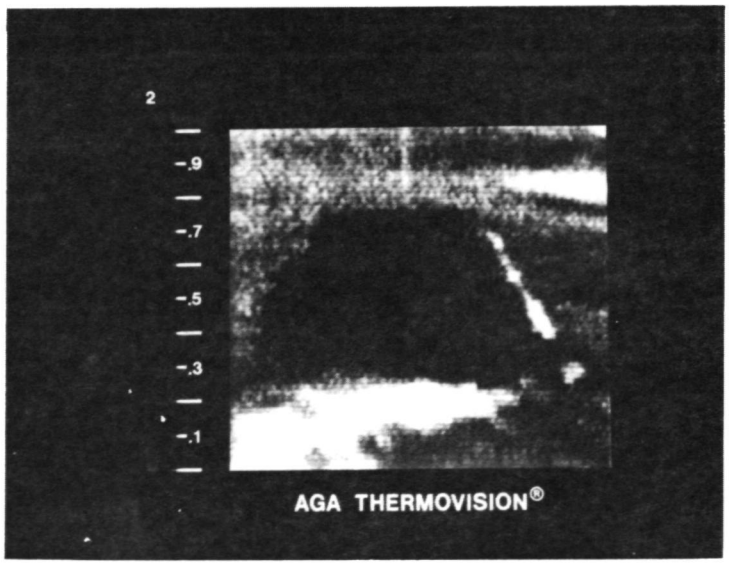


FIGURE 11. THERMOVISION IMAGE OF NINE MONTH OLD GRAVE AREA

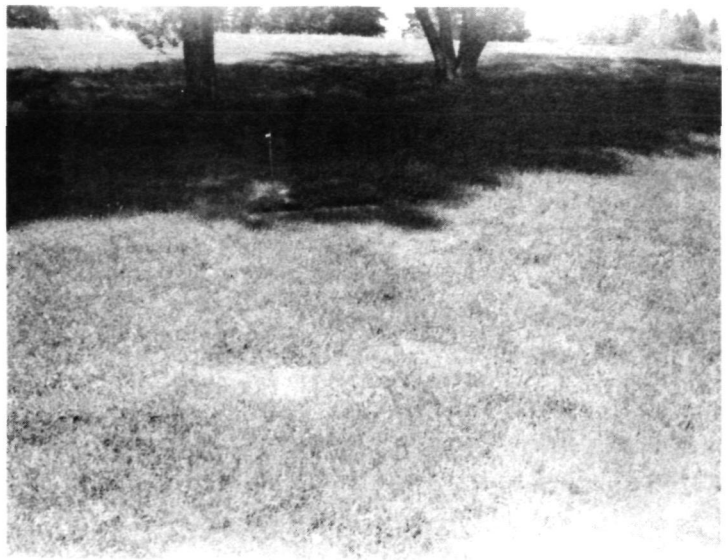


FIGURE 12. TWO YEAR OLD GRAVE AREA

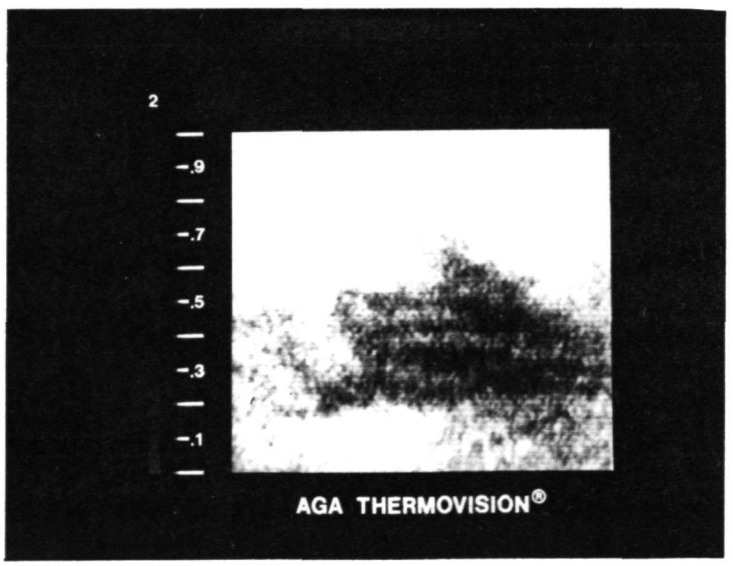


FIGURE 13. THERMOVISION IMAGE OF TWO YEAR OLD GRAVE AREA

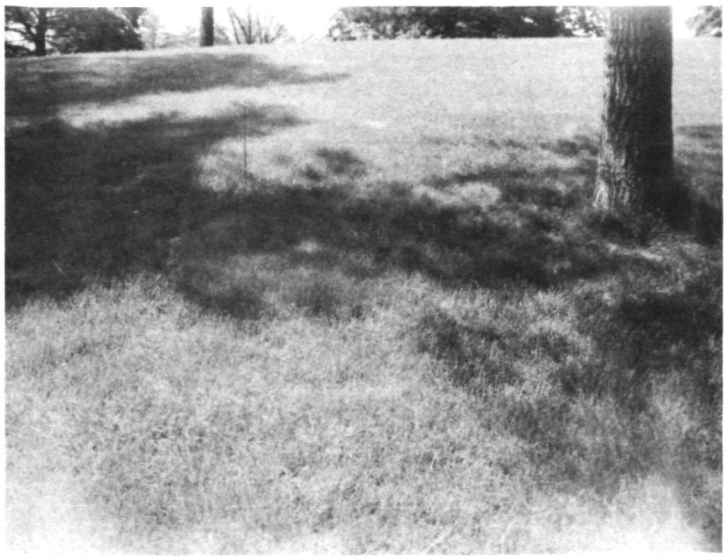


FIGURE 14. FOUR MONTH OLD GRAVE AREA

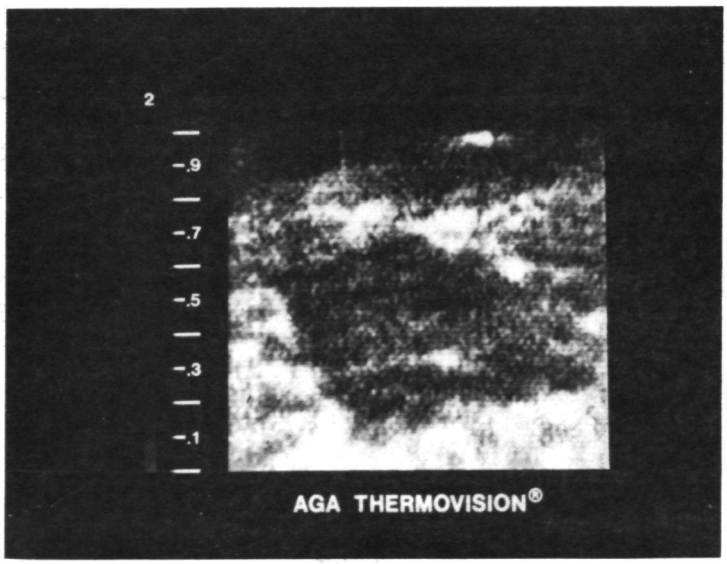


FIGURE 15. THERMOVISION IMAGE OF FOUR MONTH OLD GRAVE AREA

thermal images for grave detection. In general, the areas to be searched are large (hundreds of hectares), making the use of airborne remote sensing desirable. Discussions will be held with local law enforcement officials to consider the factors which must be taken into account in planning operational use of this technique.

APPENDIX A

NEWS ARTICLES ON MICHIGAN CONSERVATION ISSUES

This appendix contains several newspaper articles that supplement the discussions of issues of wetland management and sand mining regulation.

Wetlands Use Bill Awaits Action

BY JOHN O'CONNOR
News Lansing Bureau

LANSING — The rush to protect the swamps in Michigan is beginning

The swamps?

Yes the swamps, marshes and bogs, collectively known as "wetlands "

The bill to regulate their use and development has finally cleared the House Conservation and Recreation Committee and is awaiting floor action

The measure, according to Committee chairman Thomas Anderson D-Southgate, is the last link in a chain of environmental bills that the state has enacted in recent years to protect such fragile resources as shorelands, wildernesss, and inland lakes and streams

But the wetlands bill will be a landmark of sorts because it signals the increasingly sophisticated understanding of this unique resource that for years was considered merely wasteland by many people

"Wetlands, aren't wastelands," Anderson will argue Then the conservation chairman will rattle off a list of environmentally beneficial functions such wetlands perform in the balance of nature

Indeed the bill spells out numerous roles wetlands play including

— Wildlife habitat in the form of breeding, nesting and feeding grounds and cover for animals and waterfowl including endangered species

— Flood and storm control by the hydrologic absorption and storage capacity of wetlands

— Protection of subsurface water resources and provision for valuable watersheds and recharging ground water supplies

— Pollution treatment by serving biological and chemical oxiation basins

— Erosion control by serving as sedimentation areas and filtering basins, absorbing silt and organic matter

— Sources of nutrients in water food cycles and nursery grounds and sanctuaries for fish

The bill requires the Department of Natural Resorces (DNR) to take an inventory of the state's remaining wetlands and prepare a management plan for their protection

When the DNR's plan is drafted, public hearings will be held to get reactions to it Eventually the plan will be submitted to the legislature and the Natural Resources Commission (NRC) for approval

The bill will prevent any form of development in wetlands except under strict DNR control

The measure will however grandfather in certain existing uses of wetlands including some agricultural purposes

Developers Protest Protection Of St. John's Marshland Area

No permits for development of the St Johns Marsh near Algonac will be issued by the state pending a review of the wetlands in the 3,100-acre area

This was revealed at the July meeting of the State Natural Resources Commission after the state met its first public opposition to its proposal to preserve the marsh along Anchor Bay

The state is particularly interested in determining where the "ordinary high water mark" is in that area This will help establish which waters are public, according to Dale W Granger, chief of the Water Management Division of the Michigan Department of Natural Resources (DNR)

The area had been dedicated in September, 1974 as the St Johns Marshland Recreation Area And it was to be managed for wildlife and recreation This was done because the Legislature had appropriated $200,000 to the Parks Division to use to obtain appraisals and options on the property

But the money was never used and reverted to the State Parks Improvement Fund The DNR still does not have money to purchase the land, but the area was up for rededication by the commission as a state wildlife area

Appearing to protest the rededication were Thomas L Lott, a Detroit attorney who has an interest in 500 acres of the marsh, and Henry J Perkowski, Algonac, who wants to build apartments on 62 acres served by an existing canal

Lott questioned the authority of the state to dedicate the area, indicating this amounts to taking private property illegally He also declared that the area is not a marsh, but merely "flooded land" He maintained that there once was a golf course in the marsh

When the water recedes he asserted about 95 per cent of the 500 acres he is interested in will be dry land

Lott also told the commission that the marsh provides the only room for "realistic development in Clay Township of St Clair County site of the marsh

A Clay Twp planning report Lott said lists most of the marsh as a planned development area

Perkowski said his project has been approved by the township And he declared it is needed by the township in order to bring in the income needed to pay for a township water and sewer project He said the project would bring in $390 000 annually in taxes It also would net $691 000 in sewer fees and $230,000 in water tap-in fees he said

He said the township was forced by the state to join the county in a water-sewer program Because of that, he maintained, the township must have 1 250 new homes in order to pay for the project

Dr David H Jenkins, chief of the DNR's Wildlife Division told the commission that setting of a project boundary is merely a notice that the state wants to acquire the land It does not signify a takeover, he said He pointed out that there are islands of private property in most state areas dedicated to various management purposes

Jenkins said the acreage may be worth as much as $4 million He said 30 owners are involved, with the St Johns family the major owner There are 15 homes within the boundary he acknowledged Many of these could be excluded, he said

He also pointed out that the proposal to preserve the marsh is supported by the Lake St Clair Advisory Committee which has been raising money for the purchase of marsh land

Much was said by the two developers about the income that developing the marsh would generate Jenkins said But we haven t heard how much development would cost One of the hidden ones is illustrated by the $30 to $40 million spent by the U S Corps of Engineers to protect waterfront property he said Severe damage was caused in recent years by high water along shorelines from the St Clair River southward to Ohio

The money was spent to protect homes that were built where they shouldn't be built, Jenkins contended And he made no bones about the fact that the state wants to protect the marsh from the very kind of developers represented by Lott and Perkowski He admitted that an important area of conflict does exist between local land-use planners and the state

But Jenkins maintained that the St Johns Marsh is the one of the last, large contiguous units of marsh along the U S shoreline of Lake St Clair It is most important lying as it is in a major waterfowl flyway that the marsh remain as it is, Jenkins declared

Milliken Signs Sand-Mining Bill

LANSING (AP) — Beginning April 1, sand mining companies must restore Michigan's lakeshore dunes to their original condition after mining operations are finished

Under a law signed Friday by Gov William Milliken, dune miners will also have to get permits before mining and must file environmental impact statements

The law specifies that the Department of Natural Resources will be able to ban dune mining in areas it determines are too fragile

Milliken said the new law marks "an important milestone in assuring protection of some of Michigan's unique natural resources" and will allow future generations to enjoy the sand dunes

Rep Dennis Cawthorne, R Manistee, sponsor of the legislation said that up until now, Michigan has been one of 15 states in the country with no regulations on sand dune mining About 4 5 million tons of sand are mined in Michigan annually

The new law applies only to the dune area within 1 5 miles of the lake shorelands Currently, Cawthorne said there are about six mining operators working in approximately 10 areas along Lake Michigan

The measure's most important feature Cawthorne said, is the one making restoration of mined areas mandatory

Under the new law mining operators must file an advance mining plan with the state and meet minimum environmental standards to get their permits

There will be continuous monitoring of the mining and violators can lose their licenses

To finance the legislation mining operators will have to pay one cent per ton of sand mined within the dune area The fees are expected to total $40,000 to $50,000 annually, Cawthorne said

The measure, passed just before the legislature broke for summer recess, is considered a major victory for environmentalists, who claimed that indiscriminate mining endangered the Lake Michigan dunes in particular

REFERENCES

1. D.S. Lowe, et al., Remote Sensing in Michigan for Land Resource Management, Annual Report, 1 June 1974 through 31 May 1975, Report No. 193400-9-P, Environmental Research Institute of Michigan, September 1975.

2. _____, Remote Sensing in Michigan for Land Resource Management: Highway Impact Assessment, Report No. 190800-1-T, Environmental Research Institute of Michigan, December, 1972.

3. N.E.G. Roller, Tentative Classification of Lifeforms and Subforms of Common Michigan Wetland Vegetation, Report No. 193400-12-T, Environmental Research Institute of Michigan, July 1975.

4. N.E.G. Roller, Changes in the Wetlands and Land Use Patterns of St. John's Marsh, St. Clair County, Michigan, Report No. 193400-11-I, Environmental Research Institute of Michigan, September 1975.

5. N.E.G. Roller, Remote Sensing of Wetlands, Report No. 193400-14-T Environmental Research Institute of Michigan, In Press.

6. Jerry D. Lewis, Michigan Mineral Producers, 1974, Geological Survey Division Annual Directory No. 8, Lansing, Michigan, Department of Natural Resources, 1975.

7. John K. Koches, Dune Mining, unpublished paper prepared for the use of the West Michigan Shoreline Development Commission, 1975.

8. Michigan Department of State Highways, Aggregate Source Inventory, Lansing, Michigan State Highway Commission, 1973.

DISTRIBUTION LIST

NASA Scientific and Technical Information Facility
P.O. Box 33
College Park, Maryland 20740 (5 + Repro)

Office of University Affairs
NASA Headquarters
Washington, D.C. 20546

ATTN: Mr. J. A. Vitale, Code PY (10)